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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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VOL. CXVI.—No. 3007.] *LONDON: FRIDAY, AUGUST 17, 1923.* [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY FOREIGN POST 1s. 4d.

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And Auxiliary Machinery as supplied to the Admiralty. 2179

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Specification and Workmanship equal to Main Line Locomotives.
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See page 17, Aug. 10. 1134

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Great saving of labour. No noise No dust. No dirt. Ashes discharged 20 ft. clear of vessel.—Apply, F. J. TREWENT & PROCTOR, LTD., Naval Architects and Surveyors, 43, Billiter Bldgs., Billiter St., London, E.C. Od 4335

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TUTORS, 254, Oxford Road, Manchester. Estab. 1876. Enrol now for I.C.E. and I.M.E. Postal Courses. 100 per cent. passes last Exams. Reinforced Concrete—a new comprehensive course under expert engineer, £3 3s. Write for particulars. 968

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Tubes AND Fittings
AND
Steel Plates.
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See Advertisement, page 93. 1111

Drag Line Excavator.
Has moved 2,000 cube yards in one day. May be seen at Frodsham, near Chester. Reach 77 ft.; lift four to five tons; speed of working, one to three cuts a minute.
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Makers of
Evaporating and Distilling Plants.
Refrigerating and Ice-making Machinery.
Feed Water Heaters.
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Main Feed Pumps.
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Gas Engines Inspected, Tested and Reported upon. Over 25 years' experience. Tel.: 136 and 737 Stratford. Wire: "Rapidising, London." —Great Eastern Road, Stratford, E.15. 1794

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Builders of RAILWAY CARRIAGES, WAGONS ELECTRIC CARS, and EVERY OTHER DESCRIPTION OF RAILWAY and TRAMWAY ROLLING STOCK.
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See Advertisement page 56, Aug. 10. 3402

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For Paraffin and Crude Oil
Sizes 1½ B.HP. and upwards
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Sizes 25 to 500 B.HP.
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See advertisement alternate weeks. 9235

Centrifugals.
Pott, Cassels & Williamson,
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330
See half-page Advertisement, page 70, Aug. 3.

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER
Chief Engineer: C. B. STROMEYER, M.I.C.E.
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Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 1311

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ELECTRICAL ENGINEERING.
Professor W. H. ECCLES, D.Sc., F.R.S.
CHEMISTRY.
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The College provides practical scientific training for students who desire to become Civil, Mechanical or Electrical Engineers or Chemists.
Candidates are required to pass an Entrance Examination in Mathematics and English, but the Matriculation Certificate of any British University, and certain other qualifications, are accepted in lieu of it. The next Entrance Examination will be held on Tuesday, 18th September. Applications for admission should be forwarded to the College on forms to be obtained from the REGISTRAR. The Programme of the College may be had on application. B 47

University of London.
KING'S COLLEGE.
FACULTY OF ENGINEERING.

COMPLETE COURSES OF STUDY, extending over either three or four years, are arranged in
CIVIL, MECHANICAL and ELECTRICAL ENGINEERING
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Professor E. WILSON, M.Inst.C.E., M.I.E.E., (Dean), Electrical Engineering.
R. E. SHAWCROSS, A.M.Inst.C.E., M.I.E.E. Lecturer.
Professor S. A. F. WHITE, M.A., Mathematics.
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Considerable Extensions have been made in the Engineering Department. These include a large additional drawing-office, lecture room, and laboratory for Hydraulics and Strength of Materials in the Civil and Mechanical Departments; and research rooms, including Wireless Telegraphy, in the Electrical Engineering Department. Large additions have been made to the equipment of the Laboratories in the three Departments for purposes of teaching and research.
There is a College Hostel and a large Athletic Ground.
For full information apply to the SECRETARY, King's College, Strand, W.C. 2. B 105

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Demonstrator: S. J. ELLIS, B.Sc., A.M.I.C.E.
Lecturer on Machine Design: F. H. BODEN, B.Sc.
Assistant Lecturer on Machine Design: HENRY BAKER, B.Sc.
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Lecturers: R. O. PANTON, M.Sc.
H. W. COULTAS, M.Sc.
T. H. P. VEAL, B.Sc.
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III.—ELECTRICAL ENGINEERING.
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Lecturer: E. J. KIPPS, M.Sc., M.Inst.E.E.
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H. VICKERS, Ph.D., M.Eng.
G. M. HARVEY, B.Eng.
The FULL COURSES EXTEND OVER FOUR YEARS, and students who enter after matriculation and pass successfully the examinations at the end of each year will BE ENTITLED TO THE DEGREE OF BACHELOR OF SCIENCE in Engineering.
THE SESSION 1923-24 COMMENCES ON OCTOBER 1st, 1923.
For detailed syllabus of the Faculty with full particulars of University Regulations, Lecture and Laboratory Courses, Fees, etc., apply to the REGISTRAR. B 229

University of Manchester.
PHYSICS DEPARTMENT.

Full particulars of the Lectures and Laboratory Courses in Physics, preparing for both the Ordinary and the Honours Degrees, will be forwarded on application to the INTERNAL REGISTRAR.
Professor Bragg will meet intending Students on the 2nd and 3rd October, 10 to 1 and 2 to 4 p.m. B 344

University of Manchester.
DEPARTMENT OF ELECTRICAL ENGINEERING.

Departments of Civil, Mechanical and Electrical Engineering.
Full particulars of these Courses will be forwarded on application to the INTERNAL REGISTRAR.
The Session commences on October 4th. B 345

University of Manchester.
FACULTY OF SCIENCE.
DEPARTMENTS OF CIVIL, MECHANICAL AND ELECTRICAL ENGINEERING.

COMPLETE COURSES OF STUDY, extending over three years, lead to the University Degree in Civil, Mechanical and Electrical Engineering.
Students who have shown exceptional ability during the first year are admitted to the Honours Courses.
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Professor ROBERT BEATTIE, D.Sc., M.I.E.E. (Electrical Engineering).
Professor SYDNEY CHAPMAN, M.A., D.Sc., F.R.S. (Mathematics).
Professor ARTHUR LAPWORTH, D.Sc., LL.D., F.R.S. (Chemistry).
Professor W. L. BRAGG, M.A., F.R.S., Nobel Laureate (Physics).
Professor F. C. THOMPSON, B.Sc., D.Met. (Metallurgy).
Professor O. T. JONES, M.A., D.Sc. (Geology).
Students specialising in Water Supply and Irrigation, work under the direction of Associate Professor SANDEMAN, M.Sc., M.Inst.C.E. B 343

University of London.
UNIVERSITY COLLEGE.
FACULTY OF ENGINEERING.

THE SESSION 1923-24 BEGINS ON MONDAY, OCTOBER 1st.

The Faculty of Engineering comprises the following Departments:—
CIVIL AND MECHANICAL ENGINEERING.
E. G. COKER, M.A., D.Sc., F.R.S., M.Inst.C.E. (Dean).
C. C. COOKSON, M.Inst.C.E. (Railway Engineering).
BRYSSON CUNNINGHAM, D.Sc., B.E., F.R.S.E., M.Inst.C.E. (Waterways, Harbours and Docks).
ELECTRICAL ENGINEERING.
J. A. FLEMING, M.A., D.Sc., F.R.S. (Vice-Dean).
C. C. HAWKINS, M.A. (Electrical Design).
MUNICIPAL ENGINEERING AND SURVEYING.
M. T. M. ORMSBY, M.Inst.C.E.I.
HEATING AND VENTILATING ENGINEERING.
A. H. BARKER, B.A., B.Sc.
PHYSICS. Quain Professorship vacant.
THERMODYNAMICS.
A. W. PORTER, D.Sc., F.R.S.
GENERAL AND PHYSICAL CHEMISTRY.
F. G. DONNAN, C.B.E., M.A., Ph.D., D.Sc., F.I.C., F.R.S.
CHEMICAL ENGINEERING.
E. C. WILLIAMS, M.Sc.
APPLIED MATHEMATICS AND MECHANICS.
L. N. G. FILON, M.A., D.Sc., F.R.S.
PURE MATHEMATICS.
M. J. M. HILL, M.A., LL.D., Sc.D., F.R.S. (Acting Head of Department).
GEOLOGY.
E. J. GARWOOD, M.A., Sc.D., F.R.S.
HYGIENE AND PUBLIC HEALTH.
H. R. KENWOOD, C.M.G., M.B., D.P.H., F.C.S., F.R.S.E.

DEGREE AND DIPLOMA COURSES.
Students desirous of entering the Faculty of Engineering with a view to taking a full Degree or Diploma Course, must have passed the Matriculation Examination, or some other examination accepted in its stead.

SPECIAL COURSES.
Students who have already undergone a partial training elsewhere, and who have attained a sufficient standard, may enter for a Course occupying less than three years, and may obtain a General Certificate of Engineering after not less than two consecutive sessions' attendance.

POSTGRADUATE WORK AND RESEARCH.
Graduates in Science or Engineering, or students who have done the work equivalent to a Degree, may be admitted to Special Courses of Study or to prosecute original research.

ENTRANCE SCHOLARSHIP.
A GOLDSMID ENTRANCE SCHOLARSHIP, tenable in the Faculty of Engineering, value £120, will be competed for in September next. Application for entry forms must be made not later than SEPTEMBER 8th.

ADMISSION.
Intending Students should communicate with the Provost forthwith, and send a full statement of their previous training.

EXTENSION OF BUILDINGS.
Under the scheme of development begun four years ago, about £250,000 has been expended in buildings and equipment to increase existing facilities for training in the principles of science which form the foundation of sound engineering practice, and work is still in progress.
The new buildings, including the Charles Hawksley Hydraulic Laboratory, a Machine Tools Workshop, and a new Laboratory for Experimental Work are now in full use.
Particulars may be obtained on application to the undersigned.
WALTER W. SETON,
Secretary.
University College, London.
(Gower Street, W.C. 1.) B 346

University of Bristol.
FACULTY OF ENGINEERING.

Dean: Professor J. WERTHEIMER, B.A., D.Sc.

The SANDWICH SCHEME provides academic training for the B.Sc. DEGREE in ENGINEERING, combined with works experience with one of 21 leading engineering firms in the United Kingdom.
Prospectus from the REGISTRAR, Merchant Venturers' Technical College, Bristol. B 327

Mining Engineering
Exhibition.
THE SOUTH WALES INSTITUTE OF ENGINEERS.

In the DRILL HALL (Dumfries Place), CARDIFF, From NOVEMBER 29, to DECEMBER 8, 1923 (both dates inclusive).
Open from Two p.m. to Eight p.m., each day.

The Council of the SOUTH WALES INSTITUTE OF ENGINEERS INVITES APPLICATIONS for SPACE in the above exhibition. The last date for receiving applications is AUGUST 31, 1923.
The Drill Hall has been booked from NOVEMBER 21, to DECEMBER 14, 1923, so as to allow Exhibitors sufficient time for the erection and dismantling of Exhibits.
The Exhibition will comprise the following Exhibits:—
SCHEDULE OF EXHIBITS.
Section 1.
Scientific Measuring and Recording Instruments as applied to all branches of Engineering.
Section 2.—Steam.
Water Softening and Cooling Plant. Boilers and Equipment. Pipes, Valves, Separators, etc Drawings or Models o Modern Engines. Governors and Safety Devices, etc.
Section 3.—Electrical.
Motors of various kinds and Models of Winders, Switchgear, Cables, Controllers, etc. Electrical Tools and other Appliances. Overhead Lines. Small Motors. Electric Cranes. Telephones and Wireless Apparatus, etc., etc.
Section 4.—Mechanical.
Mechanical transmission of power above and below ground, and plant and equipment connected therewith. Bearings, Clutches, Ropes, Belts, Gearing, etc. Air Compressing Plant.
Section 5.—Workshop Appliances.
Machine Tools (Small). Pneumatic Tools. Hydraulic Tools, etc., etc.
Section 6.—General.
Shaft Signalling. Devices to prevent overwinding. Models of Pit-Cages, Tram Tipplers and Decking Devices. Models of Coke-Ovens, By-Product and Recovery Plant. Coal-Cutting and Conveying Machines. Models of Screening, Coal Washing and Sorting and Stone-Dusting Plant. Pumping Plant. Couplings, etc., etc.
Exhibits shall be as far as practicable arranged under their various Sections, but Exhibitors will be allowed when exhibiting under more than one Section, to group their exhibits on one Stand.
Forms of Application for Space, Ground Plan, etc., will be forwarded on application to MARTIN PRICE, Secretary, The South Wales Institute of Engineers, Institute Buildings, Park Place, Cardiff. A 996

Correspondence Courses for
Inst. Civil Engrs., Inst. Mech. E., London Univ. (Matric., Inter., B.Sc.), and All ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours), Assoc. M.Inst.C.E., M.R.S.I., F.R.S.A., &c. Also Day Tuition in Office. Excellent results at all Exams. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to 8/11, TRAFFORD CHAMBERS, 58, SOUTH JOHN STREET, LIVERPOOL. 1295

Engineering Salesmanship
and SALES MANAGEMENT.—Write for brochure describing our special Course of training for posts of unlimited scope in this lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 333, Oxford Road, Manchester. 1587

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Sale of Pumping
MACHINERY at HELL WATH PUMPING STATION, South Camp, Ripon, Yorkshire, by PRIVATE TENDER.

This Machinery consists of:—
Two National Oil Engines, Nos. 1990 and 1991, Horizontal Oil Engines, water cooled, T.O. type, 25 HP., 260 Revs. per minute, complete with Driving Pulleys 40 in. by 14 in., and blow lamp and spares.
Two Rees Roturbo Pumps, Nos. 4160 and 4161, Turbines on Centrifugal System, belt driven from Engine Pulley, Head 110 ft., Revs. 1260, Galls. per hour 20,000, complete with bed plate pedestals, fast and loose pulleys and striking gear.
Six Cooling Tanks, approx. 400 gallons each.
Two Oil Tanks, " 400 " "
One Water Gauge, reading to 60 lbs. per sq. in., also feet head to 140 lbs. per sq. in.
65 ft. Steam Pipe, 4 in. diameter.
Two Sluice Valves, 6 in.
Two Guards (Wire) 8 ft. by 4 ft. and 10 ft. by 4 ft.
Two Priming Cocks 1 in.
32 ft. Chequered W.I. Plates, 15 in. wide.
23 ft. " " " 18 in. "
One No. 4 Rotary Hand Pump.
One Receiver fitted with gauge and safety valve for self-starting.
One Compressor fitted with fast and loose pulley, 36 ft. Steam Pipe, 4 in.
The plant can be inspected on site by prior arrangement with Roads and Communications Officer, R.H Office, North Camp, Ripon.
Tenders in envelopes endorsed in left hand top corner "Tender for Machinery at Ripon," should be addressed to the COMMANDING ROYAL ENGINEER, 13, Wenlock Terrace, York, and should reach that office by Twelve Noon, on Monday, 3rd September. B 234

The Director-General,
INDIA STORE DEPARTMENT, Branch No. 16, Belvedere Road, Lambeth, S.E.1, requires:—
1. AXLES, STEEL, ENGINE.
2. VACUUM BRAKE GEAR.
Tenders due on the 11th September, 1923.
Tender Forms obtainable from above. B 340

NOTTINGHAM CORPORATION.
NORTH WILFORD POWER STATION.

The Nottingham Corporation invite
Tenders for the Manufacture,
DELIVERY and ERECTION of the undermentioned Engineering Works in connection with the above Power Station, viz.:—
Section "I."—STEAM, WATER and other PIPEWORK, VALVES, TANKS, etc., etc.
Specifications and Forms of Tender may be obtained from Messrs. PARNCE, CARDEW & RIDER, 8, Queen Anne's Gate, Westminster, S.W. 1, on payment of a deposit of £5 which will be refunded on receipt of a *bona fide* Tender within the prescribed time.
Extra copies of the Specifications may be obtained on payment of Ten Shillings for each copy, which will not be returnable.
Sealed Tenders, endorsed "North Wilford Power Station, Tender for Pipework, etc." must be delivered to me at my Office not later than Ten a.m. on Friday, the 14th September, 1923.
The lowest or any Tender will not necessarily be accepted, and the Corporation will not consider any Tender which is incomplete, or which does not include the whole of the work covered by the Specification.
W. J. BOARD,
Town Clerk.
Guildhall, Nottingham.
10th August, 1923. B 315

METROPOLITAN WATER BOARD.

DISPOSAL OF TWO OLD CORNISH ENGINES AT THE BOARD'S HAMMERSMITH WORKS.

The Metropolitan Water Board invite
Tenders for the Purchase and
REMOVAL of Two OLD CORNISH ENGINES Nos. 3 and 6 situated at the Board's Works, Standish Works, Hammersmith, also for the DISPOSAL of One 12 HP. GAS ENGINE by CROSSLEY with FLYWHEEL 5 ft. 6 in. diameter by 6½ in., and Two WATER CYLINDERS, GAS BAG, etc., situated at the Board's Works, Rosoman Street, Clerkenwell.
The Gas Engine is in running order and may be inspected on application at the Testing Department, Rosoman Street, Clerkenwell, E.C. 1. Either of the above may be inspected at any time between Nine a.m. and Four p.m. on week-days (Saturdays excepted) on application.
A Schedule containing particulars of the Conditions of Sale and Form of Tender may be obtained from the CHIEF ENGINEER, Metropolitan Water Board, 173, Rosebery Avenue, E.C., by personal application (Room 155), or upon forwarding a stamped addressed envelope.
Tenderers should indicate if they require forms for both of the items or one only.
Tenders must be made on the Official Form, enclosed in sealed envelopes addressed "The Clerk of the Board, Metropolitan Water Board, 173, Rosebery Avenue, Clerkenwell, E.C. 1," endorsed "Tender for the Disposal of Nos. 3 & 6 Cornish Engines, Hammersmith," and/or "12 HP. Gas Engine, Rosoman Street, Clerkenwell," and must be delivered at the Offices of the Board, not later than Eleven a.m., 3rd September, 1923.
The Board do not bind themselves to accept the highest or any Tender.
G. F. STRINGER,
Clerk of the Board.
Offices of the Board,
173, Rosebery Avenue,
Clerkenwell, E.C. 1.
13th August, 1923. B 333

METROPOLITAN WATER BOARD.

COVERED SERVICE RESERVOIR AT CHELSFIELD, KENT.

The Metropolitan Water Board invite
Tenders for the Construction
of a COVERED SERVICE RESERVOIR of a capacity of about three-quarters of a million gallons, at Chelsfield, in the Rural District of Sevenoaks, in the County of Kent.
Drawings, Conditions of Contract and Specification, may be inspected without payment of a fee, at the Offices of the Board, Chief Engineer's Department (Room 201), on and after 20th August, 1923.
Forms of Tender, Conditions of Contract, Specification, Bills of Quantities and Schedules of Prices, together with Drawings and a spare copy of the Bills of Quantities may be obtained on and after 27th August, 1923, from Mr. HENRY E. STILGOE, M.Inst.C.E., the Chief Engineer, on production of an official receipt for the sum of £10, which sum must be deposited with the Accountant to the Board, and will be returned on receipt of a *bona fide* Tender, accompanied by all the above-named documents and drawings (with the exception of the spare copy of the Bills of Quantities, which may be retained by the Tenderer).
Such payments and applications must be made between the hours of Ten a.m. and 4.30 p.m. (Saturdays Ten a.m. and Twelve noon). Cheques must be made payable to the "Metropolitan Water Board" and not to individuals.
Tenders enclosed in sealed envelopes, addressed to "The Clerk of the Board, Metropolitan Water Board, 173, Rosebery Avenue, London, E.C. 1," and endorsed "Tender for covered service reservoir at Chelsfield," must be delivered at the Offices of the Board not later than Ten a.m., Monday, 17th September, 1923.
The Board do not bind themselves to accept the lowest or any Tender.
G. F. STRINGER,
Clerk of the Board.
Offices of the Board,
New River Head,
173, Rosebery Avenue, E.C. 1.
7th August, 1923. B 324

WATER-GAS GENERATION.

UNTIL oxygen is available commercially for combustion all processes of using fuel must be subject to the heavy tax of heating up the other constituents of the atmospheric air, and the problem of recovering what is possible of the heat so lost is not likely to lose its interest for engineers. Perhaps in no other process is this loss quite so blatantly obvious as in the generation of water-gas, where for a certain fraction of the working time plant and fuel are devoted exclusively to producing huge volumes of hot gas of which as often as not no use is made after it has left the generator. It is over seventy years since the system of alternately-blowing and steaming was first introduced, and some fifty years since it began to be regularly used; but opinions are still divided as to the most efficient way of using it.

The Fuel Research Board has just issued as a Technical Paper an account by Mr. J. G. King and Engineer-Captain Fraser Shaw of observations and experiments made by them on the water-gas plant of H.M. Fuel Research Station. The actual results are embodied in a large number of tables and graphs, which well deserve study by any one who is interested in, so to speak, the life history of a water-gas generator for a few days, and the graphs in particular give striking evidence of the remarkable regularity of the process, and the constancy with which a given change of conditions will produce the same response in the product. The paper is, however, notable not only for the voluminous mass of figures included in the tables and graphs, but also for some experience that it records and some practical results to which the experiments lead.

The generator is of the Humphreys and Glasgow design, with a nominal capacity of 500,000 cub. ft. per day, or about 21,000 cub. ft. per hour, put in to supply gas of uniform quality to the various settings of the station, and up to now never used to much more than half its capacity. The gas is scrubbed and led into two 20,000 cub. ft. gas-holders, and one of the early experiences of the station was that in spite of the scrubbing and of such alterations as were tried in the supply of water to the scrubber, the gas when burnt at the rate of 5,000 cub. ft. per hour deposited about 10 lb. of dust, either as a grey sludge in the service pipes, or more often as a fine white powder in the meter outlets and pipe bends and a crust on the burners and brickwork of the retorts. About 75 per cent. of the powder was silica. It was found that 85 per cent. of it was removed by taking the gas from the holders through a long tank containing a water seal with flowing water at a constant level, and a system of baffle plates of which every one dipped into the seal. The whole was so proportioned as to pass the gas normally over the plates for about 3½ minutes with a velocity of about 53 ft. per minute; and after two years' continuous use of this arrangement the service pipes and retort combustion chambers were found comparatively free from dust.

Another experience was that, while working without any trouble with some cokes, the generator would give persistent trouble with others through clinkering. Thus a Durham coal carbonised in horizontal retorts and a Scottish coal in vertical retorts gave no trouble at all with clinker; but coke from the same Durham coal when carbonised in vertical retorts produced a clinker that hung on the walls and was difficult to remove, and, carbonised with 20 per cent. steam in vertical retorts, produced a clinker that blocked the generator up completely. To some extent this trouble was mitigated by altering the cycle of operations; but the most effective means of dealing with it was found to be to fill the space between the clinkering doors and the dead plate with fire brick, so as to prevent the accumulation of clinker over the doors. In some way this alteration, which is said to have been entirely successful for its purpose, also increased the efficiency and capacity of the generator.

The chief importance, however, of this investigation lies in the comparison it institutes between the running of the generator with the 7 ft. coke bed for which it was designed, and with 3 ft. 6 in. and 4-ft. beds, as in Dellwik-Fleischer plant. By preliminary trials it was found that a 3-ft. bed was unsatisfactory, and the cycles of blowing and steaming were selected that seemed likely to give the best results for each system, that for the 7-ft. bed being already determined. The effect of steaming differing not only with its duration but also with its direction, whether up or down; the decision of the precise cycle is not easy, and differences were found between the efficiencies of those that were chosen. In the three tests made on the relatively thin beds the totals of each cycle amounted to half a minute blow and 6 minutes gas-making, with an occasional 1-minute blow, and it was found that as against the first test some improvement could be made by reducing the quantity of steam supplied per minute. With this the generator was found to have an efficiency of 59·88 per cent. as against 57·81 per cent. for the running with 7-ft. bed. For these results 46·4 per cent. and 48·5 per cent. of the coke was consumed in the blows, as measured by the carbon found—or, strictly speaking, calculated by difference—in the blow gas.

The efficiency of the generator in its ordinary work for just on three years was about 51 per cent., and having regard to the fact that it was never used to more than about half its capacity, and sometimes to very much less or even not at all, this figure is quite up to the average of ordinary practice. The results therefore both of the working of the thin beds and of the adjustment of the cycle of operation of the full-depth bed must be regarded as decidedly satisfactory, and should be encouraging to other owners of water-gas plant who at present may be working at a lower efficiency. It must be remembered, moreover, that the thinner beds were worked under the considerable thermal disadvantage of being in a generator built for about twice their depth, and subject therefore to loss by radiation, &c., that would not have been much greater if the grate area of the generators had been large enough to produce gas at the same rate as the 7-ft. bed, which was 1·8 times as large. The authors suggest that if a 4-ft. bed were run on the cycle and under the conditions of their test in a generator with this larger grate area and with its height cut down to what would be necessary for such a bed, the efficiency would probably be about 63 per cent. The total radiation losses under the actual conditions of test having been something under 11 per cent., this seems a reasonable expectation, and the increased output would doubtless be accompanied by some saving per 1,000 cub. ft. on the power used for blowing. This is apart from any method that might be found for using the sensible heat of the water gas and the heat of the blow gas, neither of which is brought to account in the above figures of efficiency.

The net outcome of the tests seems therefore to be that where ground space is particularly scarce the deep bed has the advantage of making the most of the site for gas production, but that where works conditions are not so exacting in this respect important economies can be made by using thinner beds with a cycle of operations suitably adjusted. It may be presumed, though no results are given in the report bearing on the point, that to preserve the efficiency this cycle might have to be varied with any considerable change in the character of the coke.

Apart from the results obtained, the work described in this paper is interesting for the methods used to obtain accurate results. The final tests were all made with a single consignment of coke, which on repeated analysis proved to be very uniform in composition. The sampling and analyses were on the scale and with the care habitual in the general work of the station, an account of which is proceeding elsewhere in these columns, and to some extent balances were made not only of weights but of carbon and of heat. The reservation in regard to balances is necessary because, as in other work published by the Board, the term is used in this paper in a different sense from that in which it is understood in most engineering trials. The method of balancing depends for its authority on the fact that the items set on each side are obtained independently of each other, and the balancing of the totals is evidence of their accuracy. In the balances used in these tests, on the other hand, the last item is not an independent observation at all, but merely a difference. The thermal balance, for instance, sets the heat in the coke, steam and air supplied on the one hand against the heat recovered in the products on the other hand, leaving a difference of 11·77 per cent., which is brought in as "Difference, including radiation &c., losses." The carbon balance, again, sets the carbon in the coke charged against that found in all the products, with the exception of the blow gas, and takes the difference to be carbon in blow gas; and in the weight balance, which on the face of it is drawn in the way usual for engineering tests, the figure brought to account as carbon in blow gas is in fact not an observed value, but the difference obtained in the carbon account. With workers as careful as those of the station this may not introduce any serious risk of substantial error, and the authors were doubtless in a position to judge whether there was anything to be gained by increasing the number of their observations so as to include observed figures for the quantities included in their differences. At the same time it would be unfortunate if the check that the method of balance sheets offers against errors of experiment or observation were destroyed, as it would be if the final figure measuring the congruity of the determinations were merged in a difference that inevitably masks them; and in the interest of other work than that of the Fuel Research Station it is to be hoped that the Board and its workers will not again lend the weight of their authority to a retrograde change in the meaning of an important term.

THE GAS ENGINE POWER STATION OF PALMERS' SHIPBUILDING AND IRON COMPANY.

THE Electricity Commissioners' Report on the Generation of Electricity in Great Britain for the year ending March, 1922, showed that 17 generating stations were utilising waste heat and generating some 54,000,000 units a year from it. These figures are not large compared with the total units generated in the country, but they, of course, refer to electricity available for public distribution and do not include that generated by ironworks and other establishments for their own consumption. They also illustrate the growing importance of this application of waste heat, as the total units generated were equal to the combined totals of all oil engine and producer gas stations. It is not our purpose in this article to deal with this subject in its general aspects, but the figures of the Commissioners' Report in showing the growing utilisation of waste heat in electricity generation add interest to the technical details of any installation, and particularly to one of such importance as that which has been made by Messrs. Palmers' Shipbuilding and Iron Company, Limited, at their yard at Jarrow-on-Tyne, and which we propose to describe in some detail.

The station is quite a large one and contains seven vertical tandem gas engines of 1,500 b.h.p., and one of 1,000 b.h.p., built by the National Gas Engine Company, Limited, each engine being direct-coupled to an electric generator. There are also four 1,650 b.h.p. single-crank double-acting gas-blowing engines built by Messrs. Galloway's, Limited. The seven 1,500 b.h.p. vertical engines run at 200 r.p.m. and drive 6,000-volt alternators, which run in parallel with the public supply over the large area operated by the Newcastle Electric Supply Company. The gas is obtained from three blast furnaces, each of which produces about 1,000,000 cub. ft. of gas per hour. Of this 0·4 million cub. ft. is used for the hot stoves for heating the blast and 0·15 million cubic feet for the gas-blowing engines. In addition 0·05 ton of coal is used per furnace per hour under boilers. This leaves a surplus of 0·45 million cubic feet of gas per hour per furnace available for the generation of electricity for use in the Iron and Steel Works, Shipbuilding Yards and Marine Engineering Establishment, or for outside distribution. These figures may be compared with the corresponding figures obtained before the installation of the gas engines. These were 0·4 million cubic feet for the hot stoves and 0·6 million cubic feet for burning under the steam boilers for the blowing engines, which thus used all remaining gas after the hot stoves had been served. The old arrangement was even more unfavourable than this, however, as in

addition to the gas 0·5 tons of coal was burnt per furnace per hour under boilers or ten times the amount now required.

The hot stoves are of the vertical type, and the gas is turned into them and kept burning until the firebrick of the stove has been raised to about 800 deg. C. The gas is then cut off and the blast turned through. A dry gas-cleaning plant has been installed, and the gas is treated before passing to the stoves with the result that a higher stove temperature is obtained owing to the gas being dry and clean, and an increased blast furnace production has been made possible. In describing this interesting gas-driven power station we will first deal with the cleaning plant upon which much of its success is based, and will afterwards refer to the gas-blowing engines and gas-driven electrical plant.

The dry gas cleaning plant is of the Halberg Beth type, but considerable modifications have been made in it as compared with the original German design. It was constructed by the Fraser and Chalmers Engineering Works of Erith, and is capable of cleaning continuously 3,500,000 cub. ft. of gas per hour measured at 0 deg. C. and 30 in. barometer, and is able to carry an overload up to 25 per cent. The plant is of the type in which the gas is filtered through cloth bags and has the important advantages that the bulk of the potash can be recovered in its original state, and that the water is to a very large extent removed from the gas. This is a very important feature for gas-engine

about two years. The cooling plant, indicated at the left of Fig. 1, consists of a series of six vertical circular towers, 10 ft. in diameter and 57 ft. high, half of which are fitted with four 24 in. diameter tubes running from top to bottom of the tower and

from the upper end of which it passes forward to the pre-heaters.

The gas in passing through the cooling towers is cooled from about 200 deg. C. to about 80 deg. C., and a large amount of dust and moisture is deposited.

Fig. 1.

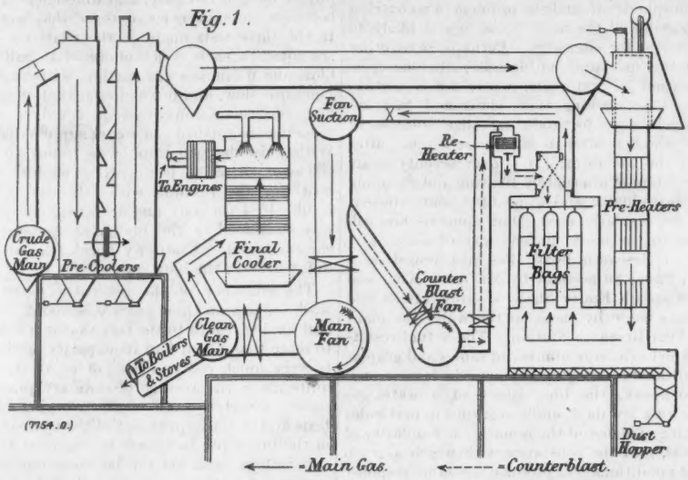


Fig. 2. Main Coolers, Cooled-Gas Inlet Pipe and Water-Sealed Valve.

Fig. 3. Main Coolers and Final Cooler.

running. The dust content of the cleaned gas is very low, averaging only 0·002 gramme per cubic metre. The total water content averages about 15 grammes per cubic metre. The plant consists of three filter units, each containing 11 double compartments. Each unit contains 264 filter bags, so that there are 792 bags in all.

A diagram illustrating the lay-out of the plant and its method of operation is given in Fig. 1 annexed. The gas before entering the filter plant proper is cooled to a temperature not exceeding 100 deg. C. and preferably to 80 deg. C., in order that the life of the filter bags may not be decreased. When the plant is in constant operation this life is

open at each end. The towers are arranged in pairs as indicated in Fig. 1, and the vertical tubes are fitted only to the towers to which the gas is first admitted. Two general views in which the pre-coolers can be seen are given in Figs. 2 and 3 above, while their actual arrangement is detailed at the left-hand side of Figs. 4 and 5, on Plate XIV. As indicated in Fig. 1, and as shown in detail in Figs. 4 and 5, the two towers of a pair are connected together by a short horizontal pipe near the bottom. Hot gas enters the top of the outer towers through rising mains connecting to the crude gas main, and passing down the outer towers travels through the horizontal connecting pieces up the inner towers

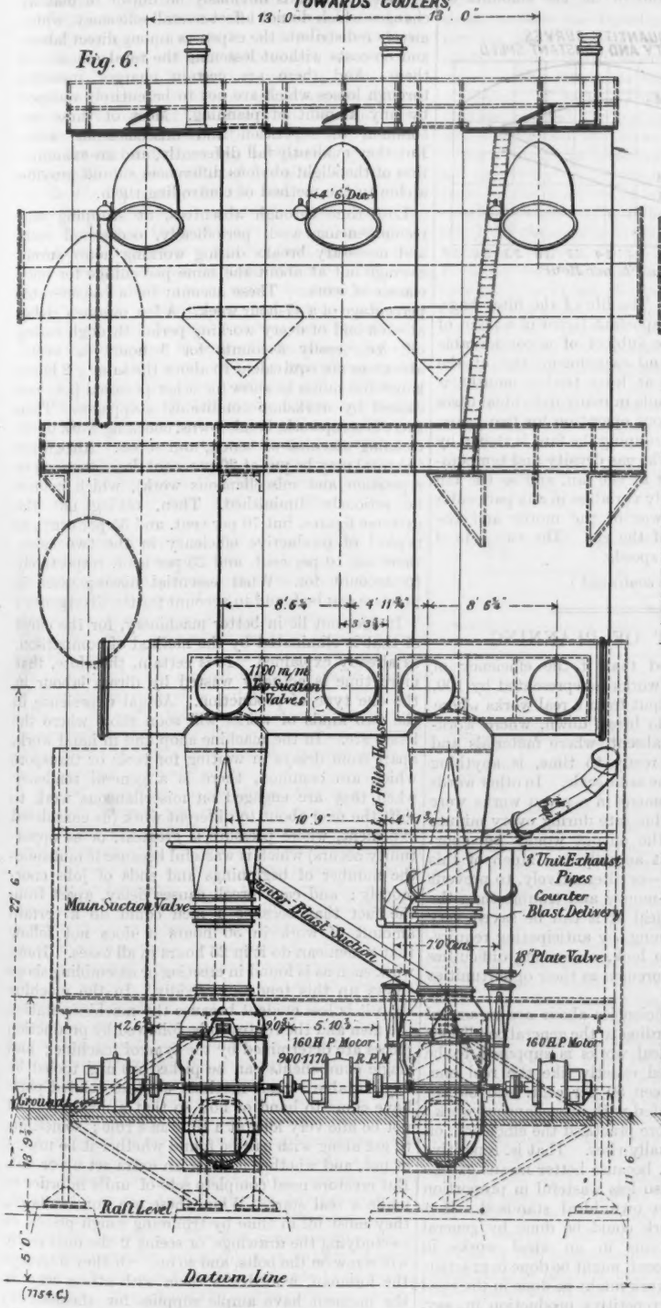
Under normal conditions natural draught through the cooler tubes and the effect of the large outside surface are sufficient to effect the necessary cooling, but in case of high furnace temperatures, or heavy load, air under pressure is sent up the tubes by means of an air nozzle placed at the bottom. As an additional safeguard, there is an arrangement at the top of each cooler whereby water can, if necessary, be run down the insides of the 24-in. tubes, the surplus water, which is quite clean, being collected at the bottom and run off to the drain. The bottom end of each tower is fitted with a cone and dust valve to collect and discharge any heavy dust which is deposited by the gas in its passage through the

coolers. As will be seen from Fig. 4, inlet and outlet valves are fitted to the coolers so that any pair may be cut out of circuit. The inlet valves are operated by chains from ground level and the outlet valves by chains from the platform which is built about two-thirds of the way up the cooler, as shown in Fig. 4. The outlet valves deliver to a common cooled gas main carried along the outside of the coolers near their top. This main can be seen in Fig. 3, but will perhaps be more easily recognised in Fig. 6, above, which is an elevation of the coolers looking towards the outlet side. The cooled gas main is also well shown in Fig. 9, on page 208, which is a general view of the upper part of the coolers looking in the same direction as Fig. 6. As will be noted this figure shows four coolers against the three of Figs. 4 to 6, an extension having been made since the drawing from which Figs. 4 to 7 were prepared was made. This cooled gas main is provided with drain cones on its underside, as shown in Figs. 4, 6 and 7, to drain off any moisture which may be deposited. The connection which leads to the inlet valves to the pre-heaters, and which is indicated as running horizontally in the diagram, Fig. 1, is actually carried downwards and up again to form a sharp angle, as shown in Figs. 2 and 4. A drain and shoot valve are fitted at the bottom of the bend, and the arrangement further assists in removing moisture and some of the heavy dust from the gas.

The purpose of the pre-heaters, the position of which in the general scheme of the plant is indicated in Fig. 1, is to heat the cooled gas up by some 10 deg. or 15 deg. C. in order that it shall pass through the cleaning plant with its moisture content superheated. This eliminates the possibility of any deposit of moisture on the filter bags which would tend to clog them up. The pre-heaters are filled with steam-heating coils and above each of them a water-sealed valve is fitted which forms the main inlet valve to the filter unit and by means of which any unit can be isolated from the crude gas supply. The main water-sealed valves are clearly shown in Figs. 4 and 5, Plate XIV, and in Fig. 10 on page 208. The header serving these valves and to which the trunk from the coolers is connected can also be seen in these figures. The bottom of each pre-heater, as can be seen in Fig. 4, is connected to the bottom compartment of a filter box, which forms a common gas chamber running the full length of the filter unit proper. The arrangement is diagrammatically shown in Fig. 1. Each filter box is divided into 11 double compartments, each compartment containing 12 bags, 8 in. diameter by 10 ft. 3 in. long, which hang vertically. They are closed at their top end by steel caps and are suspended from a mild steel frame. The bottom of each bag is open and is fitted with a spring ring so that it may be readily attached to a perforated plate. The crude gas is drawn by the main fans

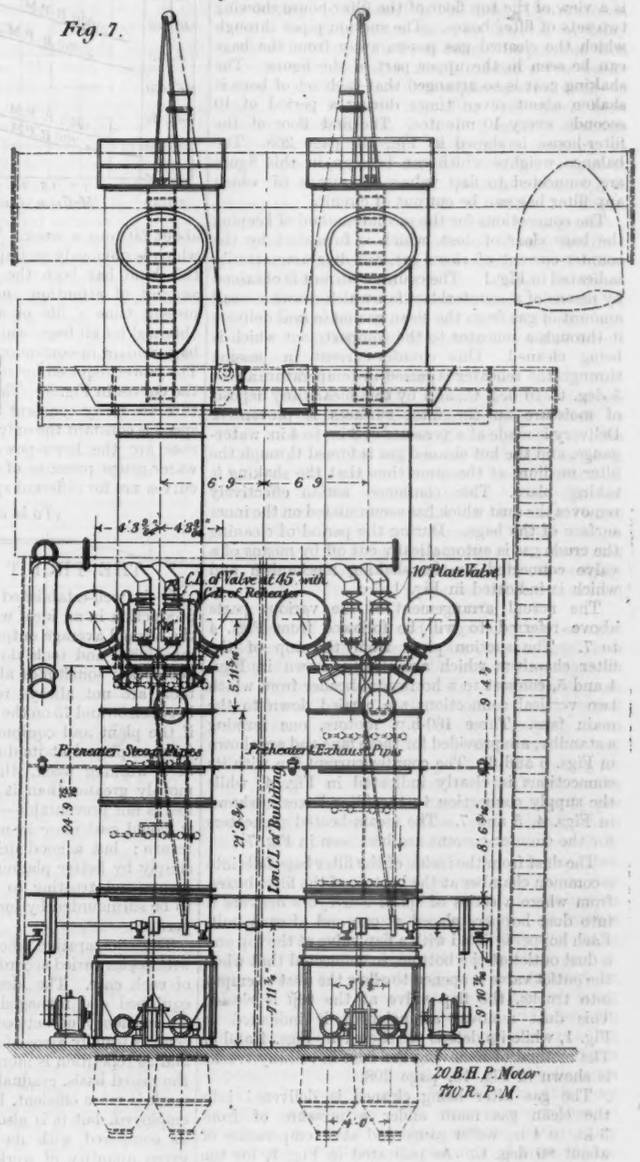
CROSS SECTION A.A. (Fig. 4.) LOOKING TOWARDS COOLERS.

Fig. 6.



CROSS SECTION A.A. (Fig. 4.) LOOKING TOWARDS PREHEATER

Fig. 7.



through the filter bags from the inside to the outside and is delivered direct to the clean gas main as indicated in Fig. 1.

The dust which collects on the inside of the bags is removed automatically and periodically by shaking the bags and by means of a counter-current of clean gas. The shaking is effected by gear at the top of the filter boxes, the shaking frame to which each set of 12 bags is connected being suspended by a central bolt passing through the top plate and connected to the shaking gear. A continuously running shaft carrying a series of eccentrics imparts the shaking motion to the frame through rocking levers. The gear is seen in Fig. 11, page 208, which is a view of the top floor of the filter-house showing two sets of filter boxes. The suction pipes through which the cleaned gas passes away from the bags can be seen in the upper part of the figure. The shaking gear is so arranged that each set of bags is shaken about seven times during a period of 10 seconds, every 10 minutes. The first floor of the filter-house is shown in Fig. 12, page 208. The balance weights which can be seen in this figure are connected to flap valves by means of which any filter bag can be cut out of circuit.

The connections for the second method of keeping the bags clear of dust, which is furnished by the counter-current of clean gas, are diagrammatically indicated in Fig. 1. The counter-current is obtained by means of a counterblast fan which draws a small amount of gas from the clean gas main and delivers it through a reheater to the compartment which is being cleaned. This counter-current in passing through the reheater is raised in temperature about 5 deg. to 10 deg. C., and by this means any deposit of moisture on the filter surfaces is prevented. Delivery is made at a pressure of 3 in. to 4 in. water-gauge, and the hot cleaned gas is forced through the filter medium at the same time that the shaking is taking place. This combined action effectively removes the dust which has accumulated on the inner surface of the bags. During the period of cleaning the crude gas is automatically cut off by means of a valve connected to the shaking mechanism and which is indicated in Fig. 1.

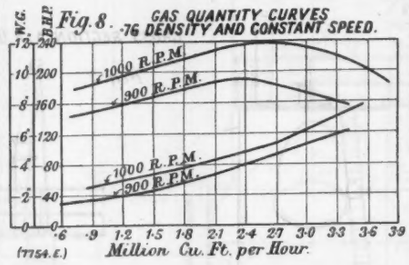
The actual arrangement of the various parts above referred to will be followed from Figs. 4 to 7. The suction pipes from the top of the filter chambers which are clearly shown in Figs. 4 and 5, connect to a horizontal header from which two vertical connections are carried down to the main fans. Three 160-h.p. motors, one forming a standby, are provided for these fans and are shown in Figs. 5 and 6. The counter-current fan with its connections is clearly indicated in Fig. 4, while the supply connection to the filter boxes is shown in Figs. 4, 5 and 7. The steam-heated preheaters for the counter-current are best seen in Fig. 7.

The dust from the inside of the filter bags falls into a common chamber at the bottom of the filter boxes, from where a series of spiral conveyors delivers it into dust hoppers placed at one end of each unit. Each hopper is fitted with a flap valve at the top and a dust outlet at the bottom, so connected that when the outlet valve is opened to allow the dust to empty into trucks, the flap valve at the top is closed. This dust removal arrangement is indicated in Fig. 1, while its details are shown in Figs. 4 and 5. The method of removing the dust in railway trucks is shown in Fig. 10, page 208.

The gas after being cleaned is delivered into the clean gas main under a pressure of from 3 in. to 4 in. water gauge and at a temperature of about 80 deg. C. As indicated in Fig. 1, for the boilers and hot stoves the gas is drawn direct from the clean gas main at this temperature, but for use in the gas engines it is cooled down to within a few degrees of the atmospheric temperature. For this purpose a final cooler has been installed and is indicated in Fig. 1. This final cooler, which is not shown in the outline drawings, but which can be seen in Fig. 3, consists of a tower 14 ft. in diameter and 30 ft. high, in which the gas passes through a water spray. A final dryer removes suspended moisture before the gas passes to the engines. The water used in the final cooler remains quite clean and may be cooled and re-used continuously.

As mentioned earlier in this description the dust content of the cleaned gas is found to average only 0·002 grammes per cubic metre. This is considerably better than the makers guarantee, which was 0·005 grammes per cubic metre for gas for the gas engines and 0·025 grammes per cubic metre for gas for boilers. Actually the gas for the engines is found to be practically 100 per cent. clean, and no dust can be found by ordinary methods, while the gas for the boilers and stoves is actually cleaner than the atmosphere usually found in the vicinity of blast furnaces or manufacturing towns. The amount of dust taken out of the gas amounts to

Fig. 8. GAS QUANTITY CURVES -76 DENSITY AND CONSTANT SPEED.



about 50 tons a week. The life of the filter bags, which is obviously an important factor in a plant of this kind has been the subject of a considerable amount of attention and experiment, and at the present time a life of at least twelve months is obtained for all bags, while in many individual cases bags remain in continuous operation for two years. The power required for running the fans is shown by the curves in Fig. 8. The gas density and temperature are fairly constant at the fan, and as the fan speed is constant the only variables in any particular case are the horse-power of the motor and the water-gauge pressure of the gas. The two sets of curves are for different speeds.

(To be continued.)

THE PROFIT OF PLANNING.

It is well-established that if the efficiency of production in an ideal works is represented by 100, the normal average output from a real works where machinery and tools do break down, where workpeople are sometimes absent, where materials and tools are not always ready to time, is anything between 50 and 75 on the same scale. In other words if the plant and equipment in a given works were fully employed at its due rate during every minute of a working week, the output would be enormously greater than it actually is. Much of this loss is not preventable—or alternatively, to prevent it would cost more in money and trouble than the return; but a good deal of it can be saved very simply by better planning, by anticipating requirements, not trusting to luck, or leaving difficulties to be surmounted by foremen as their opportunities permit.

The comparative efficiencies above are measured with scales varied according to the general conditions of each case. The ideal works is supposed to be equipped and managed exactly like the real one. An efficiency of between 50 per cent. and 60 per cent. is usually associated with miscellaneous work; and as repetition is more practised the efficiency, on the raised basis, gradually rises. That is, repetitive work is more efficient, because better means can be employed, but it is also less wasteful in proportion as compared with its own ideal standard. If a given quantity of work could be done by general non-repetitive conditions in an ideal works in 100 hours, only 50 per cent. might be done in practice. The same amount of work might be done in the ideal factory equipped for repetitive production in, say, 60 hours. But the actual production done under similar conditions might be 75 per cent. of this. Or the actual time to do the whole work would be 200 hours in one and 80 hours in the other. It is desirable to emphasise this point as it is too easily assumed that the difference between 50 per cent. and 75 per cent. arises purely from the greater mechanical efficiency of repetition work; whereas the difference referred to here is almost independent of that because the basis of comparison is varied to eliminate it. It follows that repetition work as a whole is better managed than miscellaneous work; but that is because it is easier to deal with on account of its greater stability.

However, it is evident that here is a great field for improvement requiring observation, analysis and clerical work, but little other expenditure. This is a very material advantage since most improvements require a considerable initial outlay. But is it feasible to achieve decided success by these means, or are there losses which completely offset the savings? There is obviously no object in making changes which do not affect overall efficiency, which merely redistribute the expenses among direct labour and on-costs without lessening the total amount of them. And there are certain charges incurred through losses which are not to be entirely escaped by any amount of planning. Most of these are common to repetition and miscellaneous work. But they evidently fall differently, and an examination of the slight obvious differences should provide a clue to the method of controlling them.

Lost time through absentees, at stopping and recommencing work periodically, occasional rests and necessary breaks during working hours surely average out at about the same percentage for both classes of work. These account for a considerable percentage of a 47-hour week. A few minutes' delay at each end of every working period through easing off, &c., easily accounts for 3 hours a week; absentees are equivalent to about the same; 2 hours is not too much to allow for other personal (*i.e.*, not caused by workshop conditions) stoppages. Then there is scrapwork, breakdowns, checking work done, cleaning machine or bench, and so on. Altogether the total may be put at 20 per cent. loss (common to repetition and miscellaneous work), which cannot be seriously diminished. Then, taking not the extreme figures, but 70 per cent. and 55 per cent., as typical of productive efficiency in the two cases, there are 10 per cent. and 25 per cent. respectively to account for. What essential discrepancies in practice can be found to account for the divergence?

It does not lie in better machinery, for the effect of that is eliminated by the method of comparison, as already explained. It is certain, therefore, that more time is actually wasted by direct labour in the one type of production. Actual experience in the two kinds of works will soon show where the losses are. In the machine shop and in hand work, apart from delays in waiting for tools or transport which are common, there is a general tendency when they are engaged on miscellaneous work to shift the men about to different work (as considered expedient, where pressure is greatest, or as opportunity occurs) which is wasteful because it multiplies the number of beginnings and ends of jobs enormously; and each break causes delay, apart from the fact that because 4 men could do a certain amount of work in 50 hours it does not follow that 8 men can do it in 25 hours in all cases. Hand work such as is found in erecting or assembling shops shows up this tendency vividly. In the machine shop it is less evident because the machines station the men and the routes to be followed by production pieces are determined by the type of machine; and single components can be picked up and tooled by any suitable vacant machine whether related parts have come to hand or not, so that a machine need not be idle very long at a time as a rule; something to get along with can be found whether it be urgent or not, and whether it cause an extra set-up or not. But erectors need complete sets of units in order to make a real start. When these are not available, they must fill in time by trimming rough places, or re-studying the drawings, or seeing if the nuts really will screw on the bolts, and so on. Or they intercept the foreman, who drafts them with others who at the moment have ample supplies for themselves; or he mentions that "the remaining parts won't be long; go and see if you can hurry them"; or he says "wait until I come back!" and doesn't appear free till next day. And when the laggard parts arrive the erectors work all night on Friday! But no night work, nor any effort at all can ever recover those lost hours spent slackly.

In the ideal works the work moves smoothly from station to station where men suitably equipped are in just the right force to deal with it in the manner required. And the tendency in repetition work is

towards this condition: Regular channels of flow become more or less established; there is less turbulence, less appearance of violent energy, and more useful work done. If this same tendency can be developed in miscellaneous work the 55 per cent. may soon become 60 per cent. There are, however, two grave difficulties: The first is that orders are frequently accepted for prompt execution without due regard to the amount of business already in hand; and secondly, the change from what may be termed opportunism to more definitely governed production flow is attended by apparent delay. Usually an attempt would be made to effect a change of this character within a definite and not very long period. It would be decided, perhaps, that all the work in progress up to a certain stage should continue in the manner it commenced, but that newer orders should be dealt with by carefully planning a time table and arranging production groups, or gangs with definite restricted functions, to cope with the flow. Ultimately, by the time the older orders have been executed, it is intended that everything shall be done in the new way; but for emergencies and exceptional cases a reserve gang, quite a small one, obviously cannot be done without. But since the start is made with many pressing orders—many already overdue for completion—and new ones for abnormally quick delivery must occasionally be accepted or lost to competitors, the special case tends to be the usual one, the reserve gang the principal one, and the contemplated regrouping indefinitely deferred—unless more men are engaged temporarily during the re-organisation, or delivery dates are further postponed until everything is ship-shape in the new state. More men, when the idea is to reduce costs! Delay delivery when men can be borrowed here and there from jobs less urgent!

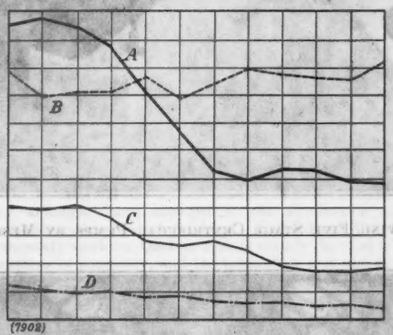
Yet a quick change, except in slack times, usually confronts the management with this dilemma: an immediate alteration to system cannot be made without extra expense if output is constant, or delay in delivery cannot be avoided if expenditure remains the same. Can it be wondered that the decision is quickly made to continue as heretofore and that the opinion which is formed of the scheduled scheme of production control is unfavourable? Theoretically it appears desirable, practically it cannot be applied, is the idea. But why a sudden change? Why not a series of small steps like natural development instead of revolution?

Where repetition is continual the practice is stabilised because the tracks are permanent, and frequently—although that is by no means a healthy state—the quantities in flow are such, in comparison with output, that at every stage there are ample reserves to be drawn on, so that regularity can be maintained on the whole despite fluctuations through temporary local weakness. Miscellaneous work lacks these favourable circumstances. But the first can be successfully imitated by process planning and the second by scheduling output according to production capacity and progressing the actual results to make adjustments in good time, just as a signalman adjusts train running to prevent collision and is not a mere watcher to record that trains have passed his box. Then the question resolves to this: Is it reasonable to expect sufficient saving by these practices to justify their maintenance?

It is not difficult to form an approximate idea, but since figures of costs are of necessity approximate, unless the gain is decisive because of its magnitude in any particular case, the truth is not always easy to extract, especially when other conditions fluctuate. The first requirement is some basis of comparison applicable to a variety of work yet accurate enough for a fair estimate to be made, and simple. Sometimes the cost per ton can be used as a measure. Or the number of hours worked may be compared with the saleable output over suitable periods; for example, it may be expressed as so many hours per hundredweight, or per cylinder, or some other unit. As a rule, although output may be miscellaneous it is fairly in well defined grooves, and the selling value may then be established firmly enough to correspond roughly with the amount of work actually done and so be used as a term in the ratio. If the calculated ratios are plotted monthly for each department general tendencies will be shown over long periods by the rise or fall of the curves, and particularly their relative movement. Thus in the diagram subjoined several departmental curves are shown calculated by the ratios.

The departmental wages cost per calendar month is taken from an actual case where repetition work was done, and the units, being small, self-contained machines, were easily calculated at the end of each month. The departments represented are A, the machine shop; B, assembling; C, tool-room; D, inspection. The monthly wages divided by the number of machines completed does not give costs, because the departments were not in phase, nor are many necessary and important factors included. But the curves do show whether improvement or the reverse is the tendency even if the movement is small. During the period (twelve months) covered, the output was steady, plant and wages remained the same, the only change was better planning in departments A, C and D. B was not affected even by the improved results from A because the reserves of stock were sufficient for steadiness there. The reduction in A was effected purely by planning to avoid waste of time, and better regulation of work flow. Tools were a large item. Economy here was won similarly and by ordering sparely. Inspection (D) gained because the output from A was steady and no reserve inspectors were necessary any longer to meet sudden rushes.

The first step towards more definite control should be the stabilisation and planning of process lay-outs. There are two ways of setting about it: First, by employing a kind of technical clerk to put down what he is told; second, engaging a highly skilled officer



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to control and direct the work. There are intermediate methods but there seems little merit in them. Either a man is good enough to control or he is not—if not, a clerk will be as useful. It is not a long job to lay-out processes in skeleton for miscellaneous work and to mark them on the tracings. Repetitive work needs more ample treatment in detail. In a works where the wages and oncosts totalled about 2,000*l.* a week the additional cost for making the lay-outs formal would be about from ¼ per cent. to ½ per cent. The cheaper man would not relieve the foremen very much; the other should take from them nearly all the trouble in settling work routes—not all, for there must be some discussion. This relief is worth something which could be expressed in output if the key were known.

The next step is to prepare production time tables. Not everything will require equal treatment, for the plant is never in perfect balance. Those parts which pass through bottle-necks of productive capacity must be carefully and fully time-tabled. But the others may not be left to chance; for nothing is more vexing, and expensive, and common than for one or two insignificant components to hold up assembling or erection because they lag far behind their associated parts. In the main, however, most of the parts can be watched by weekly output results once it is absolutely certain they are launched in production. This allows intense concentration on the weak places without demanding enormous planning capacity. Yet the task is rather beyond the cheaper grade of planner, and since the other would have ample time and capacity (presumably), to deal adequately with it, at no extra cost to the ½ per cent. in the hypothetical case, the reasons for preferring him are strong ones.

Now it is desirable for components to emerge ready for erecting at fixed dates in complete sets. Their start in production and history throughout the earlier stages are entirely subservient to the erectors' requirements. Unless they do emerge at appropriate times, either the erectors waste time in the manner suggested earlier or the commencement of erecting is deferred until suitable components are in sight to enable a healthy start to be made. This is wasteful because capital thereby lies idle longer than desirable, and intolerable when delivery is being urged. Realising the trouble at the erecting stage, managers often appoint a progress clerk to work backwards from there. This is incorrect in principle, though it does a little good. By the time the erectors show signs of being held up even though the shortage is detected in the finished part stores, there is bound to be too short an interval for delay to be entirely prevented; it cannot be possible then to make up deficiencies which existed a few weeks earlier in components which require several weeks to make. And if parts lag after they have been properly launched it is very generally through production bottle-necks. It is most necessary to keep these constantly full of work, for output is restricted to their capacity. Constant attention is necessary, and anticipation of what is ahead sufficient to be able to make suitable arrangements, for an hour lost cannot be recovered, though overtime will prevent the effect from spreading. In the case of miscellaneous work it is not always the same machines which form the bottle-neck—this month it may be gear cutters, and next it may be planing; so the easy solution of increasing the plant is not economically sound.

But with a proper time table to cover those centres likely to be weak it is a straightforward job to watch the coming load and prepare to bear it. Then, although raggedness of emergence from the machine production will not be entirely prevented, it will be far nearer the ideal level. Erection, therefore, can be regulated better. The men can be stationed with knowledge of the dates when sets will be ready to commence. There is no doubt about it—it has been done, it can be done; not, however, unless the planning be thoroughly good and the executive power behind it determined and capable.

The cost of planning and progressing has been put at ½ per cent. of the wages plus oncosts total, in a hypothetical case in a small works of very common size. It seems reasonable to expect a capable man to get ½ hour's extra work through the hard-pressed production units each week by studying them specially and looking ahead. Then, apart from any other benefit his work may produce, the gain is far more than his cost, for ½ hour, not on 47, but on the real week of less than 40 hours, represents 1¼ per cent. gain through just those weak places which control the amount of production, and consequently production as a whole benefits by 1¼ per cent. increase. Even 2 minutes extra work a day from each unit in the bottle-necks of production is sufficient to make planning pay. It makes no difference that one week the difficulty is in this and another in that—the starvation is constant. Yet no department can be reduced in strength because of sudden possibilities of being fully employed or overpressed. In repetition work the balance can be improved by installing new plant; but where the weakness flits from department to department, as in miscellaneous work it frequently does, balancing in this way becomes synonymous with reserves everywhere—which is a heavy burden without satisfactory recompense. Satisfactory planning of time tables, and progress work to act as signallers of danger can avert the collision of excessive work at one place. And though measured in time at the danger spots the saving frequently does appear insignificant, the true effect, when measured on effective total output will seldom fail to repay many times its cost.

THE CHEDDAR PUMPING STATION.

THE pumping station recently installed at Cheddar by the Bristol Waterworks Company is of special interest to waterworks engineers as an example of the application of internal combustion engines for main pumping purposes. In order to increase the quantity of water available for Bristol the Waterworks Company obtained powers to take an additional

THE CHEDDAR PUMPING STATION OF THE BRISTOL WATERWORKS.

Fig. 1. Interior of Station, Showing Five Stage Centrifugal Pumps by Messrs. Mather and Platt, Limited.

Fig. 2. Interior of Station, Showing 235-B.H.P. Cold-Starting Oil Engines, by Messrs. Ruston and Hornsby, Limited.

CHEDDAR PUMPING STATION: BRISTOL WATERWORKS.

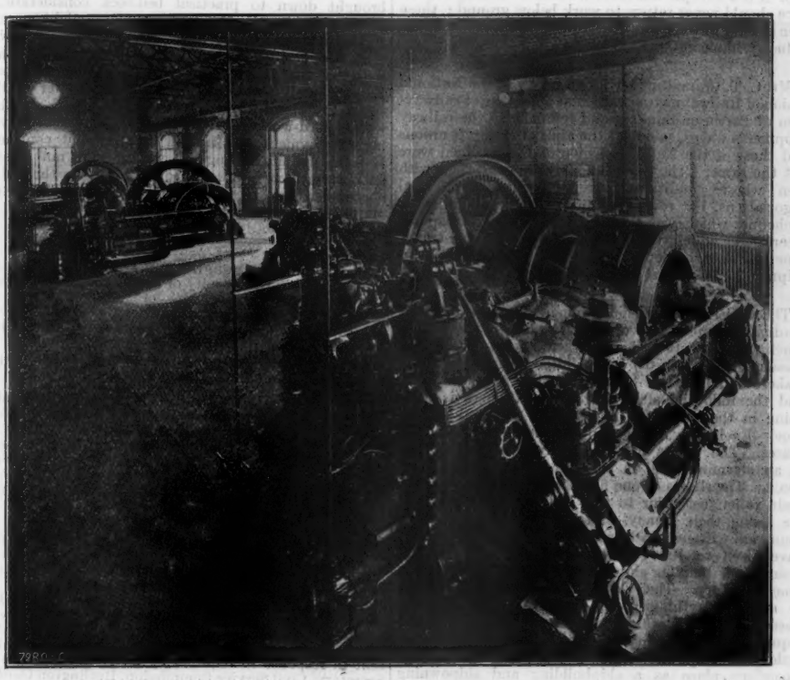


Fig. 3. Ruston 235-B.H.P. Oil Engine, showing Valve Gear.

supply from Cheddar at a point just below the famous gorge, and deliver it to their Blagdon reservoir some eleven miles distant. The new pumping station erected for this purpose is situated close to Cheddar railway station and about 1¼ miles from the intake. The pumps deliver the water directly to the reservoir through a pipe-line partly 33 in. and partly 24 in. diameter.

The station, the interior of which we illustrate on the opposite page, contains three main pumping sets. Each of these consists of a five-stage Mather & Platt turbine pump geared to a two-cylinder Ruston & Hornsby horizontal cold starting airless injection oil engine. The engines are each rated at a working load of 235 brake horse-power, and their crankshaft speed of 175 r.p.m. is raised to 1,000 revs. for the pumps by means of helical gearing of the Citroen type. The gearing arrangement is clearly shown in Fig. 1. The auxiliaries, such as the compressors for charging the starting air receivers, the fuel oil pumps, &c., are each driven by a Pelton wheel, taking high-pressure water from the delivery main.

The specification to which the plant was constructed required that each pump should deliver 1,400 gallons of water per minute against a total head of 306 ft. The official acceptance tests, carried out by Captain H. Riall Sankey were, we understand, satisfactory in every respect, the pumps delivering 1,460 gallons per minute at full load against a head in excess of 306 ft. The fuel used had a net calorific value of 17,950 B.Th.U. per lb., and with all the engines running the consumption was 956 lb. of oil per million gallons of water pumped, which is equivalent to a duty of 159 ft.-lb. per British thermal unit used. A test lasting 4½ hours on one of the engines, showed an average output of 234 brake horse-power at 168·4 r.p.m., with a consumption of 0·414 lb. of oil per brake horse-power hour. This corresponds to an efficiency of 34·2 per cent., which is highly creditable to the engine builders, although Messrs. Ruston & Hornsby, Limited, have attained a maximum efficiency of more than 35·0 per cent. on test with engines of the same type. The ability to use any kind or quality of oil as fuel and the instantaneous starting of the engine from the cold state without previous heating or other manipulation make the type a very popular one, and large numbers have been supplied to customers both at home and abroad since the design was introduced by the firm.

Chair of Mining at Leeds University.—The University of Leeds has appointed Mr. J. A. S. Ritson, Professor of Mining in the University, in succession to Professor Granville Poole, who has been elected to a professorship at Armstrong College, Newcastle-on-Tyne.

NOTES ON NEW BOOKS.

Vector analysis has on the whole made little headway amongst those engaged in the application of mathematics to physical problems. Kelland and Taits' elementary work on Quaternions, is mainly devoted to questions of geometry, and the interesting and suggestive "Dynamic" of Clifford is ill adapted for use as a text book. Of course, certain ideas have become common property, and even elementary students are taught how vectors must be added to, and subtracted from, each other. The terms "divergence" and "curl" have, moreover, been widely accepted, for certain differential operators. Nevertheless the shade of Hamilton must be disappointed at the relatively sparing use made of the concepts he introduced. The doctrine of relativity which has emphasised the fact that in our experience vectors are presented to us as a whole and not as the resultant of certain component vectors, is perhaps responsible for the revived interest in the subject, which is evidenced by the publication of a number of new text books. Amongst these we note one entitled "*Vector Analysis*," which is a translation, by Dr. H. Levy, of a work by Professor C. Runge, of which the first edition was published in 1919. The translation is issued by Messrs. Methuen and Co., Limited, at 9*s.* net. The author states in his preface that he has striven to correlate customary conceptions of vector analysis with the fundamental ideas of Grassman, but he has found it impossible to accept the latter's terminology and notation, although we note that the term external product is used for what Hamilton called the vector product. The treatise is a systematic exposition of its subject matter and should be of much assistance to that numerous body of students who are now anxious to familiarise themselves with this branch of mathematics.

In the early days of applied electricity, which hardly date back more than half a century, a great future was predicted for electrochemistry which was to revolutionise applied chemistry. At present chemistry and physics have almost become a science of electrons, but in chemical works the electrician is still required mainly as an electrical engineer and not as a chemist. "It may be said," Mr. W. R. Cooper, M.A., writes in the introduction to his "*Electrochemistry Related to Engineering*" (Constable and Co.; price 12*s.* 6*d.* net), "that engineering is becoming increasingly dependent upon electrochemistry, not, perhaps so much directly as indirectly." The electric furnaces of the metallurgists have not proved disappointing; but they are electrothermic and not electrochemical. Mr. Cooper deals in the seven chapters of his volume of 136 pages with Electrolytic Corrosion by Stray Earth Currents; Effect of Superposing Alternating Currents on Direct Currents; the Corrosion of Brass; Electric Osmosis and Cataphoresis; Electrical Precipitation of Dust, Smoke and Fumes; Electroculture; and the Relative Importance of Cheap Power and Cheap Freights. He rightly excludes electric furnaces and nitrogen fixation, electrolytic plating and refining, batteries and thermo-ionic valves. But he also omits reference in his fourth chapter to the elimination of oil from condensed water by the Davis-Perret process, the dehydration of porous materials, and electrolytic tanning and sewage treatment, matters which seem to deserve passing notices at any rate, as much possibly as the purification of clay, which he discusses at some length. He is not liberal with literature references.

The fact that a scientific text book appears in its eleventh edition and was originally published in 1867 is not necessarily a recommendation. There is hardly a modern science that has not undergone thorough reforms within the last half-century; in chemistry certainly an almost revolutionary development has taken place, and many old views have been replaced by conceptions which the older generation still finds difficult to assimilate. One need not, therefore, be favourably prejudiced, when an old friend like C. L. Bloxam's "Chemistry" is offered in an eleventh edition. The new Bloxam, "*Chemistry Inorganic and Organic, with Experiments*," is revised by Mr. Arthur G. Bloxam, F.I.C., and Dr. S. Judd Lewis, F.I.C. (London: J. and A. Churchill; price 36*s.* net). Changes were made with the tenth edition in 1913, and the present edition, in the preparation of which Mr. N. K. Smith, B.Sc., has given valuable assistance, follows the treatment then adopted, retaining the incorporation of inorganic and organic chemistry in one volume. A good deal can be done, and has been done, in 832 pages, especially with the aid of 310 illustrations and a good index. But 300 pages on organic chemistry seems little, and whether the task was not too big for one volume, is a question. The addition to the title "with experiments" and the treatment take us back to the days of the primers of Schorlemmer and Roscoe and of Ganot's physics. Such text books have their advantages, and this last revision seems to have been done conscientiously. Charcoal gas masks, the hydrogenation of oils, refrigeration, isotopes and isobars, the quantum hypothesis, valency theories and salvarsan are duly noticed, and the section on spectroscopy is re-written. But we should have expected that the importance of charcoal as a general gas absorbent would have been emphasised, and we should welcome more references there and elsewhere. Silica glass deserved a somewhat fuller notice, and we doubt whether glass is correctly defined as amorphous silica containing embedded in it invisible crystals of silica or of one or more silicates.

The desire to understand the purpose of machinery and the methods of its operations is widespread among people outside the bounds of those engaged in engineering pursuits. This is not to be wondered at when many, who have qualifications for craftsmanship and an aptitude for producing mechanical devices for the performance of simple actions, have drifted into work which gives little or no scope for their mechanical abilities. In the ranks of those are to be found many clever model makers. They have made a hobby of what might have been their normal work. This section of the community is large enough to warrant the production of a periodical and a series of books for its needs. Messrs. Percival Marshall and Co., Limited, of Farringdon-street, London, have already issued 50 volumes of their Model Engineer Series of small handbooks at 9*d.* net each, on the subjects of most interest to this public. The recent issues are "*Gear Wheels*," by Alfred W. Marshall; "*Screw Cutting*," by George Gentry; and "*Clock Repairing and Adjusting*," by W. L. Randell. They will all prove of great interest to model makers and to boys at school, who have an interest in mechanism.

In the development of a scheme of treatment of any section of design work, it is frequently the custom of authors to avoid any consideration of the processes of manufacture of the materials which are used, and to give very little information on the methods of machining adopted to put the material into suitable shape for erection. In dealing with students this action is particularly unfortunate, for although a complete understanding is impossible of attainment through the medium of a book without actual experience, much can be done to provide general and useful information which would inspire an interest in the young engineer in his later efforts to obtain thorough knowledge. Messrs. Chapman and Hall, Limited, have recently published, in association with the American house of Messrs. John Wiley and Sons, a book on "*Structural Drafting and the Design of Details*," at a price of 25*s.* net. In it the author, Professor Carlton

Thomas Bishop, of the Sheffield Scientific School of Yale University, has devoted some part of his work to the associated matters of the rolling of steel sections and the fabrication of composite structures. An outline of the organisation of a structural company is also provided for the information of the student reader. The work is divided into three parts, of which the first is devoted to introductory matter and concerns the subjects referred to and others preliminary to actual design. The common routine work in the design of structures is treated in the second part. In this section, the practical significance of the work is emphasised much more than is commonly the case in text books prepared by British authors. Erection plans and diagrams, as well as the preparation of orders for materials from the stores have not been neglected. The design of details forms the subject matter of the third part, which is opened with a treatment of the stresses operating on structures, the shear and bending moment diagrams and the design of the tension and compression members of any composite type. The volume is completed with tables and diagrams relating to the weights, dimensions and safe loads of the standard sections adopted by the American steel manufacturers.

INDUSTRIAL NOTES.

The National Appointments Committee (Ministry of Labour and Officers' Association) is a committee concerned with assisting those ex-officers and men who have not had a fair opportunity since demobilisation of restarting their civil career. It is the earnest desire to clear the remaining cases off without delay, if possible before the end of this year. The number of such ex-officers and men on the register of the Appointments department at the beginning of the year was 11,464; to-day it is 5,941, and there seems to be good reason to hope that with renewed and concerted effort this latter figure can be satisfactorily reduced.

Negotiations between the Transport and General Workers' Union and the National Union of Railwaymen have led to the formulation of a scheme for co-operative action. The scheme is to be gone into at a joint conference of representatives of the two bodies to be held to-morrow in London. A joint manifesto issued by these unions refers to the fact that employers amalgamate, form combines and come to understandings one with another. The united front of the employers can only be attacked by a united front on the part of the workers. As the employers co-operate for the production of the employers' profits, so must the operatives co-operate to increase their wages and improve the conditions under which they toil. The two unions sound the call for a united front of the workers engaged in the railway and road transport branches of industry. The manifesto also speaks of eliminating all non-unionists.

Mr. J. S. Woodsworth, member for Central Winnipeg in the Dominion House of Commons, has received a letter from Mr. Arthur Henderson, Secretary of the British Labour Party, intimating that if the Dominions will co-operate it is proposed to hold a British Empire Labour Conference next year. Mr. Woodsworth states that from this conference, which will be held on the occasion of the opening of the Empire Exhibition, the formation of a Labour political organisation for the whole Empire may result. Mr. Henderson has asked the Dominions for their views on the meeting. Mr. Woodsworth adds that he will take up the matter at once with the heads of the various organisations in Canada.

The report recently issued by the Miners' Nystagmus Committee of the Medical Research Council states the following:—

1. The official figures for this eye disease show an apparent increase.

2. The cases, however, fall into two groups:—

(1) Severe cases of the type recognised as incapacitating in France and Belgium. This group has not increased in these countries in recent years, and appears even to have diminished as the safety lamps have improved.

(2) Cases in which the psychological element largely predominated owing to the wide interpretation placed upon the definition of the disease in the schedule of the Workmen's Compensation Act. This group is the one which has increased the reported cases.

3. The decision as to whether any given case belongs to Group 1 or Group 2 is purely a medical question, and should be left to medical men who have had special experience of the disease.

4. Most cases of miners' nystagmus are only partially incapacitated cases; they benefit physically and psychologically by work. Some require work above ground; others are fit for suitable work below ground. All men in this group should receive every encouragement to start work as soon as possible.

5. A few exceptional cases with short mining experience should never return to work below ground; these men should in their own interests be drafted out of the industry immediately.

Mr. C. T. Cramp, industrial secretary of the National Union of Railwaymen, speaking at a meeting of railwaymen at Perth, on Sunday, and referring to the railway shopmen's wages, said that the aims of the craft unions and those of the National Union of Railwaymen were not the same. The craft unions were concerned with men whose conditions were determined by local negotiations, but railway shopmen were paid from an exchequer which was filled by the sale of transport; whereas, he added, war wages in the engineering trades generally had come down by 16*s.* 6*d.*, the railway shipmen had only lost 10*s.*

The boilermakers' dispute remains unsettled and is gradually involving every day a larger number of other workers. It is dealt with in the report for the present month, issued by the United Society of Boilermakers and Iron and Steel Shipbuilders, in which we find the following statement:—". . . There is little doing in the shipyards, and that is reflected on the Stock Exchange in the quotations of shipbuilding shares. The values of these shares are going down at an alarming rate, in some cases amounting to a panic. The shares of one firm stand at about one-half their value just prior to this lock-out. Shareholders are losing their money, and trade is going to other countries. French trade is flourishing; French exports have risen to 100 per cent. over pre-war exports. Germany is building ships to-day quicker than at any time in history. Their latest cargo vessels are superior to almost anything owned by British shipowners. These new ships are more economical, and it only requires a continuance of the present blockade by Federated shipbuilders to put this country in a secondary place as a shipbuilding and shipowning nation. . . ." This statement needs no comment, since our readers know how the dispute originated. They will be able to estimate at its right value the patriotism which has dictated it.

The strike in the London docks is still unsettled, and is likely to remain so indefinitely, seeing that the strikers are receiving unemployment relief from the Guardians at the expense of the ratepayers. An appeal has been addressed to the Government on this matter, and we understand that steps are to be taken to test the legality of such payments.

The Prime Minister, Mr. Stanley Baldwin, replied, on the 3rd inst., to the letter, of July 24, of Sir Allan Smith, chairman of the Industrial Group, on the question of unemployment, to which we referred on page 151 *ante*. Mr. Baldwin stated that the real and lasting cure for unemployment was to be found in the restoration of stable conditions throughout the world and in the development of new markets; the Government had these points in hand and were also working for the development of our Imperial resources and the increase of inter-Imperial trade. In regard to home trade, a certain amount of electrification had now been put in hand by the Southern Railway Group, and considerable improvement had been, and was being, undertaken on the Tubes. While guarantees under the Trade Facilities Act will be available, it would be unreasonable to give a Government subsidy to any works. The financial arrangements for the Port of London Authority dock extension scheme have been settled, and the actual obtaining of tenders for the work is only awaiting the settlement of suitable labour conditions. Mr. Baldwin added that he was not at present convinced that there were good grounds for the establishment of a further formal committee of business men as suggested by the Industrial group. His own experience convinced him that it was of greater value and much more acceptable to hard-worked men of business to be invited to give their advice and assistance on particular and definite questions rather than to be asked to undertake wide and general investigations.

Sir Allan Smith sent a lengthy reply to the Prime Minister, dated the 11th inst. He found that the prospects for the restoration of stable conditions throughout the world were not encouraging. In regard to the increase of our Imperial trade, Sir Allan said that if the Group had had the opportunity of meeting the Prime Minister, they could have indicated in a number of respects how this particular point might be dealt with immediately; (he pointed out a number of large contracts which could be placed). The work in this country which the Government were considering was largely unskilled work. He reviewed again the various points made in his letter above referred to, and added that the difficulty was that the investigations of the Government up till now had been too wide and of too general a description, they had not been brought down to practical bed-rock considerations. It was in order that the Government might get the spontaneous assistance of experts in a practical way that the Group made their suggestions, and they regretted that it had been received in such a manner. It was surely somewhat of a satire to refer at this stage to "hard-worked men of business." If they were "hard-worked," it was for the purpose of providing employment and not in carrying out contracts. If some definite feeling of security were not created within the next few weeks, or at latest by the end of September, no recovery would be possible before March of next year at the earliest.

University College, London.—A Goldsmid Scholarship, tenable in the Faculty of Engineering at University college, London, of the value of 120*l.* (40*l.* a year for three years, subject to satisfactory progress) will be offered for competition at an examination to be held at the college in September. Particulars may be obtained on application to the Secretary of the College.

Reduction of Light Dues.—The Board of Trade, after consultation with representatives of the Advisory Committee of Shipowners on New Lighthouse Works, has decided to reduce the light dues as from October 1 next to a scale 20 per cent. below the statutory rates. A draft Order in Council to give effect to this decision has been laid before both Houses of Parliament in accordance with Statute.

Engineering Department: General Post Office.—The Civil Service Commissioners announce that an open competitive examination for not fewer than 12 situations as probationary assistant engineer in the Engineer-in-Chief's Department of the General Post Office, will be held in London, commencing on November 6. The limits of age are 20 and 25, with certain extensions. Regulations and form of application will be sent in response to requests by letter addressed to the Secretary, Civil Service Commission, Burlington Gardens, London, W. 1.

Tests of an Ebste Brunner Back Pressure Steam Turbine: Addendum.—The table on page 152 of our issue of August 3 last was printed as received from Professor Dresdner. In this, the term effective pressure is used which is not an English expression and this was understood to be equivalent to absolute pressure. It has, however, been suggested by a correspondent that gauge pressure may have been intended. In that case the ratio of expansion will be less than was assumed, and the reheat factor will be about 104·5 instead of 107·5. This brings the hydraulic efficiency up to about 80·3 per cent., which is nearly as good as that of the Brush-Ljungström turbine at Walsall, as recorded on page 578 of our issue of May 11 last.

Cooper's-Hill War Memorial Prize.—The above prize, which has been founded by members of the Royal Indian Engineering College, Cooper's-hill, in commemoration of members of the College who fell during the war, is awarded annually by the Institution of Civil Engineers and triennially in turn by the Institution of Electrical Engineers, the School of Military Engineering, Chatham, and the School of Forestry, Oxford. The prize, which consists of (*a*) A bronze medal; (*b*) a parchment certificate of award; (*c*) a money prize of the value of about 25*l.*, is given for the best paper on a professional subject selected by the Council making the award. One of the triennial awards falls this year to the Council of the Institution of Electrical Engineers, who have selected for the subject of competitive monographs "An Historical and Critical Survey of Atmospheric Electricity and Protection against Lighting." Papers submitted for the above purpose should reach the Secretary of the Institution not later than December 31, 1923. The Institution of Electrical Engineers award for 1923 is limited to Corporate Members of the Institution who were under 30 years of age on January 1, 1923.

Rebuilding of Piccadilly-circus Station.—Piccadilly-circus Underground station is to be rebuilt. The new station will be about 15 ft. immediately beneath the circus, and will be oval in shape, with a large circulating area, from which separate escalators will connect with the Bakerloo and Piccadilly lines, thus dispensing with the present lift service. In all there will be six escalators. Three will feed the Bakerloo Tube, and three the Piccadilly Tube. The centre escalator in each group will be reversible, so that during the morning, evening and theatre peaks, two escalators in each group can be run in either an upward or downward direction. The saving in time to the passengers will be considerable. 15 passimeters will be installed. A broad subway under the circus, completely encircling the booking hall, will be a feature of the new station. Seven entrances will be provided: Two on either side of Regent-street, two on either side of Messrs. Swan and Edgar's, one at the corner of Glasshouse-street, one at the corner of Shaftesbury-avenue, one at the site of the present Tube station. The subways will be available to the general public for crossing the circus. During the work of reconstruction every effort will be made to inconvenience the public as little as possible.

AN AIR LUBRICATED MICHELL BEARING.

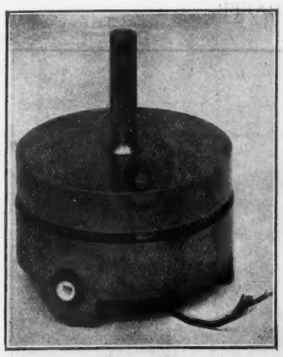


FIG. 1.

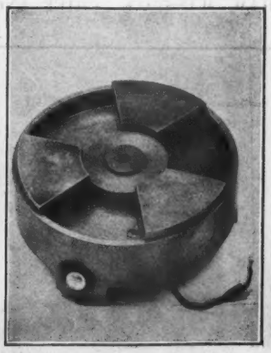


FIG. 2.

FIG. 3.

WE illustrate above in Figs. 1, 2 and 3, a very interesting model constructed by Mr. Albert Kingsbury, to demonstrate the principle of the Michell thrust block. Mr. Albert Kingsbury, it should be added, is an independent inventor of the pivotted pad as applied to thrust blocks, and those constructed in America are made under his patents.

The model consists of two parts, a solid collar about 5½ in. in diameter and 1 in. thick and weighing about 5¾ lb., and a baseplate or stand on which are mounted three Michell pads, pivotted behind their centres of figure in accordance with the Michell principle. The collar is shown separately in Fig. 3, and the base with its three pads in place is represented in Fig. 2, whilst Fig. 1 shows the collar resting on the pads with which it is kept concentric by means of the pin visible in Fig. 3, which fits into an insulated bush, which can be seen in Fig. 2. If the surfaces of the collar and of the pads are carefully wiped free from oil, there is, of course, metallic contact between the collar and the pads, as is made evident by means of a small battery and electric lamp arranged in the base of the model. On touching the collar with the free lead the lamp lights up so long as the collar is at rest. If, however, the latter is set in rotation by means of the knurled spindle shown, air is dragged in between the collars and the pads so that the collar actually floats on air, the solid surfaces being nowhere in contact. This is demonstrated by the fact that the lamp does not light up when the free lead is brought into contact with the surface of the collar. Indeed, a considerable pressure can be exerted on the top of the spindle without breaking down the insulation. The frictional resistance offered by the air film is very small, and once started in rotation the spin is prolonged for a surprising length of time, but when the motion becomes too slow to compress the air dragged in to the necessary extent the stoppage is nearly instantaneous. A peculiar feature of the model is that it will not operate unless the rubbing surfaces are clear of oil. This behaviour is in accord with practical experience which has shown that with whatever lubricant a Michell block is operated the supply must be ample. The model was on view at the recent conversazione of the Institution of Civil Engineers and is to be shown by Michell Bearings, Limited, of South Benwell, Newcastle-on-Tyne, at the forthcoming Olympia Exhibition. It affords a very striking demonstration of the accuracy of Osborne Reynold's theory of lubrication.

AUTOMATIC GAS-REGULATING VALVES.

ON page 659 of our issue of November 24 last we illustrated and described a regulating valve, known as the "Losles," used for automatically maintaining a constant temperature in rooms and ovens heated by gas. The supply of gas, it may be remembered, was controlled by the vapour pressure of a volatile liquid contained in a closed metallic capsule, the capsule expanding and closing the valve when the temperature exceeded the desired degree and *vice versâ*. Since the above-mentioned article appeared a number of improvements and developments of the system have been made and we now propose to refer briefly to these.

Reference to the illustration which accompanied our previous article will show that the gas passing through the valve came into contact with a part of the corrugated diaphragm which forms the working surface of the metallic capsule. The gas would therefore exert a cooling effect on the liquid in the capsule, and this cooling effect would tend to counteract the heating effect of the air in the room or oven acting on the exposed portion of the capsule. To avoid this effect, valves used for controlling the temperature of rooms or ovens now have a pad of heat-insulating material fitted over the working face of the capsule, the material being placed so as to prevent the gas from coming into contact with the capsule. The temperature of the latter is thus practically unaffected by the temperature of the gas, so that the action of the valve is dependent only on the temperature of the air in the room or oven.

Valves supplied for regulating the temperature of domestic ovens are now fitted with more convenient means for adjusting the temperature setting. This was formerly effected by means of a knurled-headed screw acting on the corrugated diaphragm of the capsule through the medium of a helical spring. The screw, however, has now been replaced by a short lever working in a graduated sector box arranged so that the lever can be locked in any one of five positions giving that number of different working temperatures; these are indicated approximately by the words "High," "Medium" and "Low" engraved on the side of the sector box. A knurled-headed screw is still used for adjusting the temperature setting of valves used with industrial ovens, and such valves are being extensively employed on the large ovens installed in catering establishments as well as on ovens for lacquering, japanning and other similar work.

Valves designed on exactly the same principle have recently been constructed for regulating the temperature of water and other liquids in open heaters or circulators heated by gas. In these valves, the volatile liquid is contained in a short stout stem which is screwed into the heating vessel or into a tee piece fitted on the circulating pipe. They are made for three temperature ranges, viz., 100 deg. F. to 140 deg. F., 140 deg. to 180 deg. F., and 180 deg. to 212 deg. F., valves with the last-mentioned range being particularly suitable for use in cafés, hospitals and other institutions where a supply of boiling water is constantly required; they may also be employed on gas-heated glue pots, *bains-Marie*, etc.

The only other valve to which reference need now be made is known as the "Losles" remote-control valve from the fact that the volatile liquid is contained in a small cylindrical bulb separate from the valve itself and connected to the expanding capsule of the latter by a small-bore metal tube. These valves are suitable for controlling the temperature of type-metal pots, and particularly for use in connection with fish frying and other culinary operations involving the use of heated oil. In such cases, the bulb is immersed in the oil and the valve fitted into the gas-supply pipe, the opening of the valve being regulated by the expansion and contraction of the metal capsule which, as previously mentioned, is connected to the bulb by means of a small-bore tube. These valves are suitable for temperatures ranging from 330 deg. to 400 deg. F., but the maker, Mr. George Wilkinson, Beech Mount, Otley Road, Harrogate, is now engaged in experiments with a view to rendering them suitable for controlling temperatures exceeding 500 deg. F. and also to obtain temperature regulation between very close limits.

BRITISH BRANCH WORKS IN CANADA.—H.M. Trade Commissioner at Toronto states that a number of United Kingdom manufacturers are believed to be considering the matter of branch works in Canada, particularly in Ontario and Quebec Provinces. These include makers of artificial silk yarn and engineering lines.

THE RAND WATER SUPPLY AND VAAL RIVER BARRAGE.

THE Rand Water Board was constituted in 1903, to take over a number of independent water supplies, with the object of bringing about a better use of the resources available. On the Board are representatives of the gold-mining industry, and of the municipalities concerned, in equal numbers, with in addition a representative of the railways, and a chairman appointed by the Governor-General of South Africa. In 1905, when the Board took over the supplies then available and began to distribute water, the total quantity sold amounted to 851,129,292 gallons. Last year the amount sold reached 4,151,607,050 gallons. Almost the whole of the original supplies were drawn from shafts and bores sunk about 17½ miles south of Johannesburg, and supplies were furnished to that city and to Germiston. Gradually the resources were developed, and it was possible the next year to supply Roodepoort-Maraisburg. In the year following supplies were extended to the Springs Municipality, and in 1908–9 to Benoni and Boksburg. Two years later Krugersdorp was served, and in 1920–21 supplies were for the first time made to Brakpan. The area now served is 1,793 sq. miles in extent, with a population of 575,329.

The Board's first chief engineer was Mr. D. Leitch, M.Inst.C.E., who first of all set about developing the supplies of underground water by bores at Zwartkopjes, in the Klip River Valley. This for a time sufficed, but the continued extension of the service made it necessary, on Mr. W. Ingham being appointed chief engineer in 1910, to look for further supplies. These were procured by development at the original Zuurbekom station, where the output was raised from about 2,500,000 gallons to 7·3 million gallons per diem. This increase showed no prospect of satisfying ultimate requirements, however, and the chief engineer was ordered in 1910 to report on practicable schemes within a radius of 50 miles of Johannesburg. After a while the project known as the Vaal River scheme was embarked upon and has been carried out to the plans and under the direction of Mr. W. Ingham, M.Inst.C.E., who still holds the post of chief engineer to the Board.

The Vaal River scheme involved as its essential feature a barrage across the Vaal River capable of impounding 13,633,000,000 gallons. After all deductions this quantity is sufficient for a daily supply of 20,000,000 gallons for a year, even if no water entered the reservoir in that period. The barrage was commenced in 1916 and has recently been put into commission. The programme concurrently completed embraced arrangements for a first supply from this source of 5,000,000 gallons daily, a second instalment of 5,000,000 gallons being now under consideration. The latter has been approved, but work on it is not being proceeded with for the moment. The first supply was inaugurated on July 27, by His Royal Highness Prince Arthur of Connaught. We give an illustration of the finished barrage in Fig. 1 on page 204, while Fig. 2 shows a plan at the site and Fig. 3 a plan of the barrage piers to a rather larger scale.

Before dealing with the barrage itself it will be well to explain that it is situated about 25 miles below Vereeniging. Water is drawn from the reservoir through intake works by means of pumping stations at Vereeniging, about 23½ miles above the barrage. The main pumping station here forces the supply against a head of 480 ft. to the pumping station at Zwartkopjes, a distance of 26 miles, whence it is pumped to the Forest Hill reservoir at Johannesburg (against 1,100 ft. head), and to Boksburg (against 820 ft.).

The barrage was described, during construction, in our columns in 1921,* and we need not therefore enter ir to all the details again. It has a length of 1,400 ft., the original river channel of 620 ft. having been enlarged to this extent in order to compensate for the obstruction of the piers, and to allow ample margin for floods. The waterway provided is approximately 40 per cent. in excess of the largest recorded flood. The barrage consists of 36 openings for gates 30 ft. 6 in. wide. The piers which are 8 ft. thick are 34 ft. 6 in. high and 55 ft. long. They are perpendicular on the up-stream side and provided with a toe down-stream running on to a long apron which extends 100 ft. down-stream. At the edge of the apron is a dwarf wall, 3 ft. high, so that a pool is formed to reduce the scouring effect of the water issuing beneath the sluices under high head. Rock extended all across the river at the site which was so favourable that the maximum depth to which the pier foundations were carried was only about 6 ft. below the rock surface. The whole of the barrage piers, foundations and apron were constructed of concrete, the foundations being reinforced with rails.

Above the barrage, and running the whole length of it is a reinforced concrete superstructure, 36 ft. 5 in. high. On the top of this is arranged the operating

* See ENGINEERING, Vol. cxii, p. 325.

THE VAAL RIVER BARRAGE.

CONSTRUCTED TO THE DESIGN OF MR. W. INGHAM, M.INST.C.E., CHIEF ENGINEER.

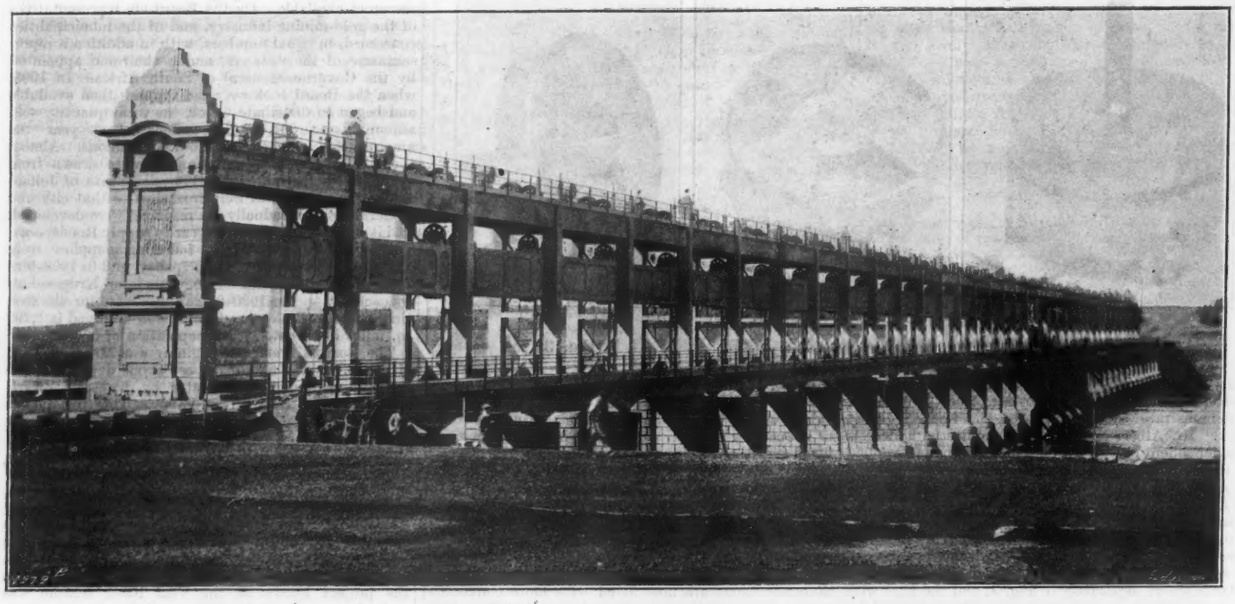
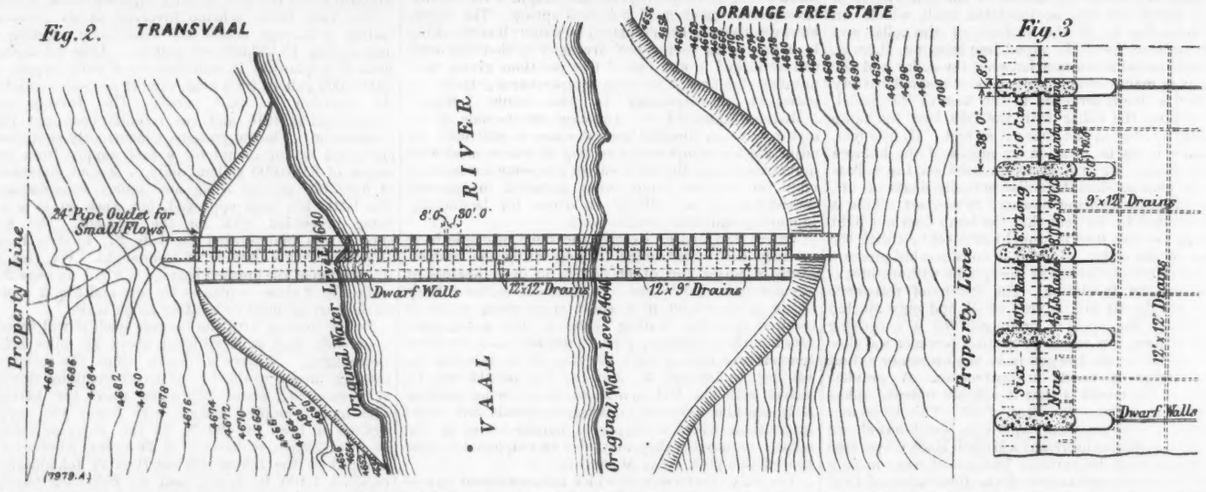


Fig. 1.



platform from which the gates are lifted, the latter being hoisted into the bays between the columns. The gates are 25 ft. high, 32 ft. 6 in. wide and weigh 28 tons. They are of the free roller type and were supplied by Messrs. Glenfield and Kennedy, Limited, of Kilmarnock. Each is provided with a counterweight of about 62 tons, the latter moving through about half the distance the gate rises or falls. These gates were described in the paper read by Mr. Bruce Ball at the summer meeting of the Institution of Mechanical Engineers,* and an admirable description of the operating gear was there given. The gates can be opened in 1¼ minutes each, and take three men to close in about 20 minutes each.

The depth of water at the barrage when the reservoir is full is 25 ft. 1 in., when the water surface covers 6½ sq. miles and extends 40 miles up-stream. The maximum width of the impounded water is about 4,000 ft. On the up-stream side of the barrage is a track for a travelling gantry capable of handling the gates. A spare gate can be lowered into slots in the piers by this gantry when repairs to the sluices gates are necessary. On the down-stream side of the structure the barrage carries a Government road bridge across the river. This has a road width of 10 ft. with a narrow footpath on either side with a passing place in the centre where the total width is increased from 15½ ft. to 23 ft. between railings.

The pumping plant at Vereeniging really consists of two stations. One at the intake on the river and one about a mile distant therefrom. The latter pumps the water up to Zwartkopjes while the former simply draws from the reservoir to supply the main station at which the water is subjected to treatment before being sent on. At the intake works are two centrifugal pumps driven each by a 185 b.h.p. motor of the three-phase asynchronous type working on 2,000-volt 50-cycle 3-phase current supplied from the main pumping plant. These pumps are specially designed to deal with silt laden water, the solids often amounting in the Vaal River water to 1,500 parts per 1,000,000. From this plant the water is pumped through a 33-in. pipe to the main station, where the water, treated with sulphate of alumina, is delivered to sedimentation tanks, four of which have been constructed, each 260 ft. long by 70 ft. wide and 8½ ft. deep, and capable together of dealing with 6,000,000 gallons per diem. After leaving these the water is passed through rapid Paterson gravity filters. From the filters the water is delivered by two pumps to a clear water reservoir, 300 ft. in diameter and 11 ft. deep, constructed of reinforced concrete throughout. The main pumps consist of two sets of Allen turbine-driven centrifugals. The turbines run at 4,700 r.p.m. and are geared down through double helical gears to the speed of the pumps, viz., 900 r.p.m. The latter are four-stage units. Steam is supplied to these and to two generating sets by three Babcock and Wilcox boilers, each of a capacity of 8,000 lb. of water per hour at 200 lb. pressure and superheating to 600 deg. F. Forced draught is used and the chimney is 45 ft. high. The electrical plant consists of two Allen-Metropolitan-Vickers turbo-driven alternators of 350 kw. rating at full load and generating three-phase current at 2,000 volts and 50 cycles. This furnishes the power for the intake and the filter pumps.

In order to deal with this enhanced supply the Zwartkopjes station has been enlarged by the addition of a new boiler with a capacity of 20,000 ft. of steam per hour, and two turbo-driven centrifugal sets capable together of dealing per diem with 5,500,000 gallons against 1,150 ft. head. A 5,000,000 gallon service reservoir has also been added at this station.

The total cost of this work has been about 1,320,400*l.*, of which 455,000*l.* were expended upon the barrage and weirs which stand good for the whole 20,000,000 gallon scheme. It is estimated that the second unit would cost only about 500,000*l.* to arrange for. Altogether the Board has 262 miles of mains at the present time, of which 140 miles are pumping mains, 54½ miles being laid in connection with the Vaal River scheme. It is interesting to note that though the numbers of the community served are not large, about three-eighths of the supply goes to the city of Johannesburg itself and approximately the same amount to the

* See page 28 *ante*.

SMALL POWER CIRCULAR SAW BENCH.

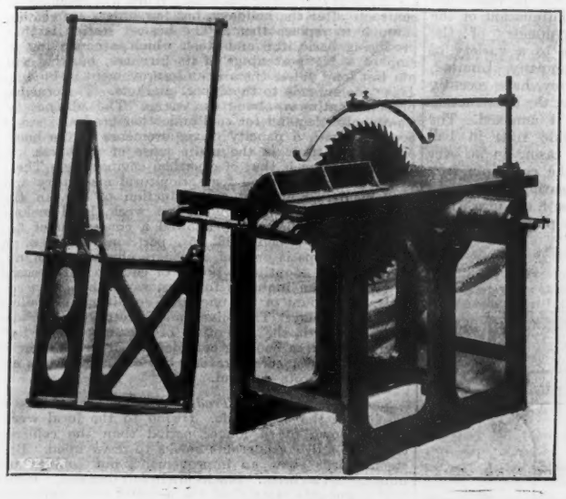


FIG. 1.

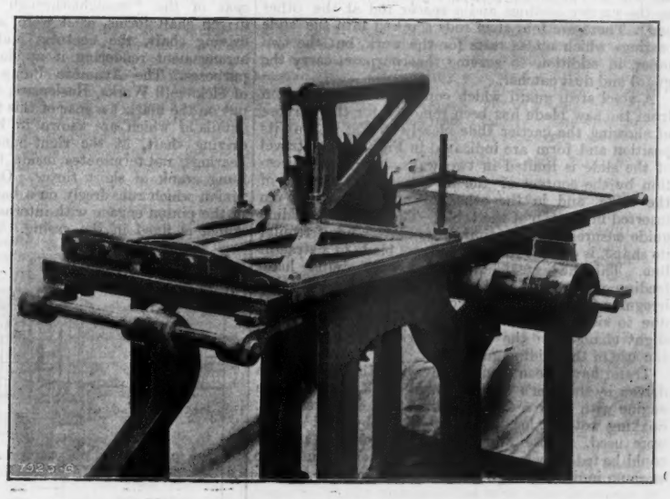
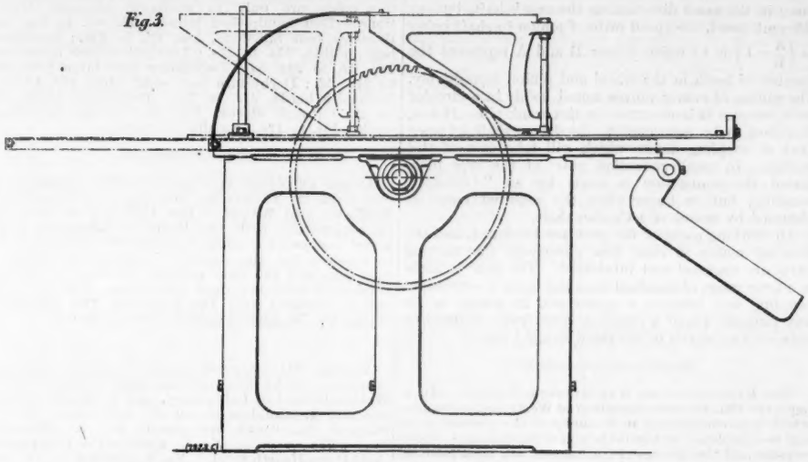
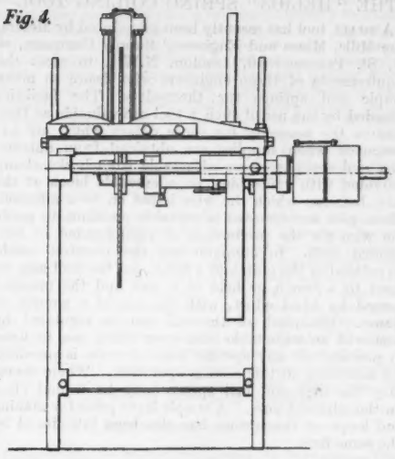
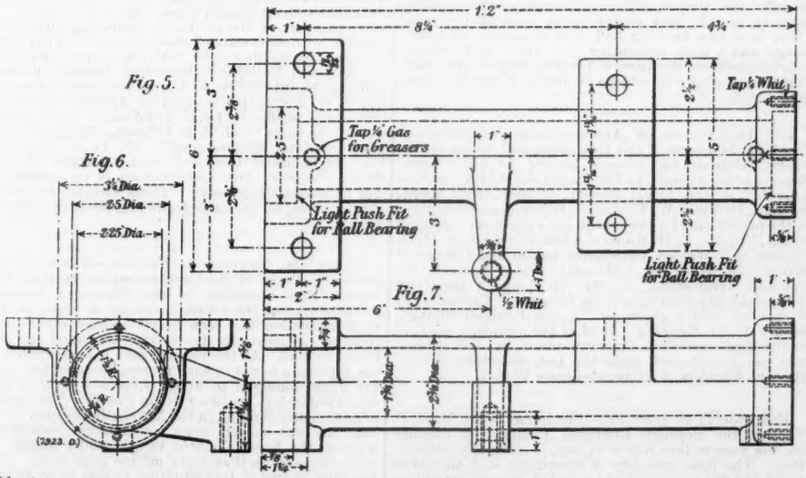


FIG. 2.







gold-mining industry. The only other large consumers are the railways taking about 360,000,000 gallons per annum. The balance is split up among the seven other municipalities named above.

SMALL POWER CIRCULAR SAW BENCH.

MESSRS. DRUMMOND BROTHERS, LIMITED, of Guildford, added to their standard productions some time ago a 3 b.h.p. paraffin engine which we described in ENGINEERING, vol. cxiv., page 707. Having produced a well-designed and finished engine at a price competitive with those for inferior sets of foreign origin, they have since then introduced a number of standard machines, such as an electric lighting set and a concrete mixer, of suitable design to be driven by the engine. The most recent addition to the series is a circular saw bench which is illustrated above. The production of a reliable and satisfactory tool of this type requiring only 3 h.p. for its drive at full capacity, must be regarded as a very good achievement. The power needed has been kept down by the use of ball bearings for the saw spindle and by the introduction of a sliding guide for the work, which is so constructed as to reduce the possibility of binding the saw by side pressure.

Fig. 1 shows the machine set for use with sawn or planed material as a plain bench and with the sliding guide removed but shown beside it. The table is a planed casting provided with ribs on its underside to give rigidity and also with cast pads for the attachment of the bearing housings for the saw spindle. At the front end two brackets are bolted to the underside of the table to carry the cross rod on which the fence slides and to which it may be locked, by a clamp screw when in position; as is seen in Figs. 2, 3 and 4 the fence can be swung out of position to give accommodation for the sliding guide. A strip of the table is removable by the disconnection of two screws at each end to allow the same to be taken out and replaced. The spindle is made of mild steel and mounted in two ball bearings which are both carried in the same solid housing, the form of which is shown in Figs. 5 to 7. The driving spindle has a diameter of 1¼ in., but has a shoulder turned on the saw end against which the one bearing rests while the other ball race is forced against a smaller shoulder at the other end. A driving flange is pinned to the spindle, and this carries a pin to suit the driving hole in the saw blade while a second flange holds the saw in position. A guard of the common leaf type is provided and is carried on steel rods as is shown in Fig. 1. Fast and loose pulleys are mounted on the end of the spindle, and the striker gear is so arranged that the handle is in a convenient position below the table. The machine is erected on two main side castings ribbed around the edges and leg frets, and provided with lugs for attachment to the table. These are also tied by cross bars made of angle iron.

The sliding guard and guide is built up on two outside angles to which are attached two thin fretted

castings. The angles act as slides on the sides of the table, which are machined for the purpose, and they are kept at the proper distance apart by a strip bolted to the carrier castings and a spacer rod at the other end. There are four steel rods screwed into the slide castings which act as rests for the work, but the two inner, in addition to serving that purpose, carry the guard and dust catcher.

A steel strip guard which completes the protection from the saw blade has been removed for the purpose of showing the carrier slide clearly in Fig. 2, but its position and form are indicated in Fig. 3. The travel of the slide is limited in two ways, in the one direction by the contact of the tie bar against the end of the table, and in the other by contact with a pin inserted in the top of the table. The use of the sliding guide ensures that the timber, no matter how irregular its shape, is carried towards the saw blade in a straight line. This has great advantages over simple hand feeding on the plain table in the case of logs and other irregular forms. All the excessive power requirement due to side pressure on the saw blade arising from slight changes on the line of working, is avoided by the use of this sliding guide.

Tests have been conducted with the saw bench driven by the firm's "Willing Worker" 3 b.h.p. paraffin engine with both a 20 in. and a 24 in. diameter saws. Soaking wet oak logs of about 18 in. by 9 in. section were used. These were cut through as fast as they could be fed forward with reasonable care, and there were no indications of overloading the engine.

THE "HELIOS" SPRING COILING TOOL.

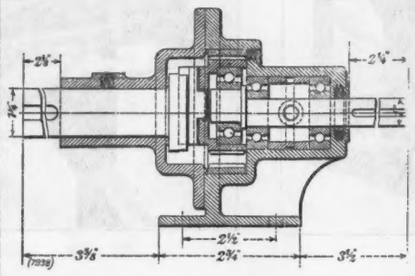
A small tool has recently been introduced by Messrs. The Mills, Mines and Engineers' Supply Company, of 24, St. Pancras-road, London, N.W.1, to meet the requirements of those engineers who desire to make simple coil springs for themselves. The facilities afforded by the use of such a tool are valuable as they remove the necessity for those delays which are experienced when supplies are obtained from outside. The tool consists of an adjustable wrench-like clamp provided with guide pins, on a movable block at the side, between which the wire is fed on to a mandrel. These pins are situated in suitable positions to guide the wire for the production of right-handed or left-handed coils. In common use the mandrel would be rotated in the clutch of a lathe, but the tool may be fixed to a bench or held in a vice and the mandrel turned by hand effort, with the use of a wrench or clamp. The pitch of the coil can be regulated by means of an adjustable feed lever which can be fixed in position for any specific job. A scale is provided for assistance in this setting operation. Where necessary the first and last spirals may be wound close on the adjacent ones. A simple lever press for making end loops on the springs has also been introduced by the same firm.

Notes on New Books: Erratum.—We much regret that in our notice, appearing on page 172 of our last issue, of Sabatier's "*Catalysis in Organic Chemistry*," translated by Professor E. Emmet Reid, it was stated by mistake that the publishers of this translation were the University Press, London. The publishers' name should have been given as the Library Press.

The Iron and Steel Institute.—The Autumn Meeting of this institute will be held at the Chamber of Commerce, Milan (Via Mercanti 2-4), on Monday and Tuesday, September 17 and 18, commencing at 9.30 a.m. on each day. At the conclusion of the meeting visits have been arranged to Florence, Rome, Piombino, Leghorn, Genoa and Turin. The following is the list of papers which it is expected will be submitted to the meeting: 1. C. R. Austin, "Alloys in the Ternary System Iron-Chromium-Carbon." 2. E. D. Campbell, W. L. Fink and J. F. Ross, "The Iron-Iron Carbide Equilibrium in Dry Hydrogen at 950 deg. C." 3. E. D. Campbell, J. F. Ross and W. L. Fink, "The Relative Efficiency of Dry and of Moist Hydrogen on the Decarburisation of steel at 950 deg. C., and the effect of Hydrogen on the Phosphorus Content." 4. C. A. Edwards and L. B. Pfeil, "A Note on Coarse Currugation in Mild Steel Sheets." 5. G. E. Flack, "The Iron and Stee. Industry of Italy." 6. F. Giolliti, "The Complex Action of Manganese and of other so-called Deoxidising Agents in the Manufacture of Steel." 7. W. T. Griffiths, "The Change Points in some Nickel-Chromium Steels." 8. W. H. Hatfield, "The Influence of Nickel and Chromium upon the Solubility of Steel (in relation to Corrosion)." 9. Cesare Martelli and Tito Sotgia, "The Iron Ore Mines of Nurra (Sardinia)." 10. A. Portevin, "The Morphology of Pro-Eutectoid Cementite," 11. A. Portevin, "The Corrosion Cracking of Steel under the Influence of Internal Stresses." 12. S. H. Rees, "The Effect of Low Temperature Annealing on some Mechanical Properties of Cold Drawn Steels." 13. H. Styri, "Theory and Practice of Steel Refining." 14. C. Vanzetti, "The Manufacture of Heavy Steel Castings from Small Converters," 15. H. C. Wang, "Grain Growth in Iron and Steel."

THE AVAMORE REDUCTION GEAR.

There are numerous uses for a simple reduction gear of the "straight-through" type in which the driven shaft forms, as it were, a continuation of the driving shaft, the neatness and symmetry of the arrangement rendering it applicable to a variety of purposes. The Avamore Pump Company, Limited, of Sicklemill Works, Haslemere, Surrey, have recently put on the market a gear of this type, the construction details of which are shown in Fig. 1 annexed. The driving shaft, at the right-hand side runs in ball bearings, and terminates inside the casing in an over hung crank of short throw. On the crank-pin is a pinion which runs freely on a ball bearing. The teeth of the pinion engage with internal teeth cut in a wheel which is fixed in the casing. The pinion rotates in



space in the same direction as the crankshaft, but at different speed, the speed ratio of pinion to shaft being as $\left(\frac{A}{B}-1\right)$ is to unity, where B and A represent the number of teeth in the wheel and pinion respectively. The pinion of course moves round bodily in a circular path because it is mounted on the crank-pin. It has, therefore to be connected to the driven shaft by some kind of coupling device which will take care of this motion. In small reduction gears of the type illustrated the connection is made by an "Oldham" coupling, but in larger sizes the required result is obtained by means of a Cardan shaft.

All working parts of the gear are hardened, and the drawing makes it clear how effectively the moving parts are enclosed and lubricated. The gear is made in a large range of standard sizes and forms a convenient coupling unit between a motor and its pump, or for any purpose where a constant speed ratio is required between two shafts in the same straight line.

The Rebuilding of Westminster Station.—It is expected that the reconstruction of Westminster Station, which was commenced in January of the present year, will be completed by about the end of September. Westminster and the Houses of Parliament will then have an entirely new station which will increase the working capacity of this busy centre by at least 50 per cent. There is a new booking hall with a battery of passimeters and a wide circulating area which is a distinct improvement on the narrow booking hall of the early Victorian period. A scheme of bright tiling has been introduced.

The Institution of Aeronautical Engineers.—The 1923–24 session of this Institution will commence on Friday, October 12, when a lecture entitled "Some Aspects of an Attempt to Fly Round the World," will be delivered at the Royal Society of Arts, John-street, Adelphi, by Major W. T. Blake. Other interesting items in the programme for the session are a paper on "Soaring Flight," by Dr. E. H. Hankin, a lecture by Mr. A. H. G. Fokker on "Welded Tube Construction and Cantilever Wings," a paper on "'Leader' Cable Systems for Steering Aeroplanes," by Mr. W. Loth, a paper on "Rigid Airship Structures" by Lieutenant-Colonel V. C. Richmond, and a paper on "Lower-Powered Flying" by Mr. W. O. Manning. Most of the meetings are held at the Engineers' Club, Coventry-street, but full particulars can be obtained from the hon. secretary, Mr. L. Howard-Flanders, 60, Chancery-lane, W.C. 2.

Electricity in Stepney.—The report of Mr. W. C. P. Tapper, the Borough Electrical Engineer of Stepney for the year ending March 31 last, is distinctly satisfactory. The total quantity of electricity sold amounted to 34,418,923 units and the number of new consumers eclipsed the total of any previous year. The gross profit during the year was 137,066*l.*, which is nearly 14 per cent. on the averaged capital expenditure and over 20 per cent. on the balance of outstanding loans. After meeting loan interest and sinking funds and other items chargeable against gross profit, a net profit of 65,645*l.* has been earned notwithstanding reductions in the price of electricity equivalent to 46,750*l.* during the year. The greater part of this profit has been rightly used in writing off non-existent assets. The total works generating cost for the year was 0·966*d.* per unit, the capital charges 0·51*d.*, giving a total cost of 1·467*d.* per unit.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—Conditions in the heavy trades show few signs of increasing business. Work was resumed on contracts after the holidays, but few orders are coming through to replace them. The busiest section is that producing basic iron and steel, which is contriving to employ a big percentage of its furnaces, but this will not last long unless there is an improvement in buying. This tone extends to the export markets. The crucible branch continues about the same. The absence of Continental demand for tool and other grades of steels combined with a paucity of requirements in the home engineering trade is the main cause of weakness. A brighter section is that of electrical engineering. There is also a brisk demand for agricultural machinery and implements. Following the reduction of 10*s.* in the price of Siemens' acid billets last week, local makers of soft basic billets have allowed a concession of 5*s.*, quotations now being 28*l.* 5*s.* per ton. Business in bars and hoops is only of a meagre character. Manufacturers are adopting a policy of caution with regard to the Russian inquiries for files, saws and engineers' tools, on account of the uncertain conditions prevailing in that country. The silver and electro plate trades are quiet with the exception of the spoon and fork section, which is booking considerable orders. There is a ready sale for safety razors, but ordinary razors are only in moderate demand.

South Yorkshire Coal Trade.—A moderate business is passing in the coal trade. Owing to the local works closing down for a longer period than the collieries there are still considerable stocks to draw upon. Best steam hards show an improvement, but cobbles and nuts are not so brisk. Slacks are in fair demand. House coal merchants state that the demand is exceptionally low, even for this time of year. Good business is being done in furnace and foundry coke, with prices unaltered. Gas cokes are only in moderate request. Quotations:—Best handpicked branch, 32*s.* 6*d.* to 34*s.* 6*d.*; Barnsley best Silkstone, 26*s.* 6*d.* to 28*s.*; Derbyshire best brights, 25*s.* to 27*s.*; Derbyshire best house coal, 22*s.* 6*d.* to 23*s.* 6*d.*; Derbyshire best large nuts, 20*s.* to 21*s.* 6*d.*; Derbyshire best small nuts, 15*s.* to 16*s.*; Yorkshire hards, 21*s.* to 23*s.*; Derbyshire hards, 20*s.* to 22*s.*; Rough slacks, 11*s.* 6*d.* to 13*s.* 6*d.*; Nutty slacks, 10*s.* to 12*s.*; Smalls, 7*s.* to 9*s.*

Award of National Certificates in Chemistry to Students in Technical Schools and Colleges in England and Wales.—The Institute of Chemistry, in conjunction with the Board of Education, is prepared to approve schemes, submitted by technical schools or colleges, for the award of certificates relating to part-time and full-time grouped courses in chemistry conducted under approved conditions. Full particulars can be obtained from The Registrar, The Institute of Chemistry, 30, Russell-square, London, W.C.1.

British Standardised Steel Samples.—Standards issued jointly by The Iron and Steel Institute and The National Physical Laboratory, and at present available are No. 1.—Sulphur (S.=0·027 per cent). No. 2.—Sulphur (S.=0·071 per cent.). No. 3.—Phosphorus (P.=0·029 per cent.). No. 5.—Carbon (C.=0·65 per cent.) Acid Open-Hearth Steel. No. 6.—Carbon (C.=0·10 per cent.) Basic Open-Hearth Steel. These samples are supplied, post free, at 21*s.* per bottle containing 50 grammes, together with certificate of standardisation. They can be obtained, by sending order with remittance, direct from The Physical National Laboratory, (Metallurgy Dept.), Teddington, Middlesex, or by post or application from Dr. C. H. Desch, Department of Applied Science, The University, Sheffield; Dr. C. A. Edwards, The University College, Swansea; Col. E. L. Johnson, Cleveland Technical Institute, Middlesbrough. Mr. D. A. MacCullum, West of Scotland Iron and Steel Institute, 93, Hope Street, Glasgow. Other samples are in preparation and will be issued when ready. These samples can also be obtained from all chemists dealing regularly in laboratory ware.

Heavy Oil Engines in France.—The Commercial Secretary, Paris, of the Department of Overseas Trade reports that according to the *Temps* of August 4, the attention of the Under-Secretary of State for Technical Education has been drawn to the importance of training specialists in the working of Diesel and Semi-Diesel motors. At the present time it is estimated that the aggregate power of such motors operated throughout the world amounts to about 4,000,000 h.p., of which only 150,000 h.p. are in service in France. The disparity is particularly striking in the Mercantile Marine. France has only one motor cargo vessel under construction, whereas the fleet of motor vessels under foreign flags amounts to more than three million gross tons. One of the chief causes of this situation is said to be found in the general ignorance regarding the possibilities of heavy oil motors. Moreover some manufacturers hesitate to utilise Diesel motors from the fear that they will not be able to find the necessary specialists. In these circumstances M. Gaston Vidal has decided that the theoretical and practical study of Diesel and Semi-Diesel motors is to form part of the instruction given in the various schools under his department. Courses on the subject will be organised in the national schools of arts and crafts, the national professional schools and in the industrial practical schools. A special course will be arranged in Paris for manufacturers and engineers who wish to obtain full information on the subject.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Extreme quietness characterises the Cleveland pig-iron trade. With customers still holding off the market in anticipation of further all in values, the outlook is discouraging. No. 1 is as scarce as ever, and the value is maintained at 110*s.*; whilst No. 3 g.m.b. keeps steady at 102*s.* 6*d.*; No. 4 foundry is offered freely at 97*s.* 6*d.*; and No. 4 forge is 95*s.* to 96*s.*—all f.o.t. makers' works, or f.o.b. Tees. There is not a great deal of the last-mentioned quality available for the open market, makers consuming a good deal of the output at their steelworks.

Hematite.—The situation as regards the East Coast hematite branch is undergoing a change. With output much reduced by furnaces becoming inoperative, makers are taking a much firmer stand, and prices are moving upward once more. A rise of 6*d.* advances Nos. 1, 2 and 3 to 98*s.* 6*d.* both for home consumption and for shipment abroad—a figure which is still altogether unremunerative. No. 1 is put at a shilling above mixed Nos.

Foreign Ore.—Nothing new is ascertainable concerning imported ore. Business is stagnant, and best rubio remains nominally 23*s.* c.i.f. Tees.

Blast Furnace Coke.—Durham blast furnace coke is less scarce and is easier in price. To local consumers the concession quotation ranges from 40*s.* to 41*s.* delivered.

Manufactured Iron and Steel.—The various branches of the finished iron and steel trades are in a much less satisfactory state than could be wished. Many manufacturers are short of work, and are keenly seeking orders with the result that whilst recognised market quotations are not altered, no hesitation is shown to make price concessions to secure contracts. Common iron bars are 12*l.*; iron rivets, 14*l.*; packing (parallel), 8*l.* 10*s.*; packing (tapered), 11*l.* 10*s.*; steel billets (soft), 9*l.*; steel billets (medium), 10*l.*; steel billets (hard), 10*l.* 5*s.*; steel boiler plates, 14*l.*; steel ship, bridge, and tank plates, 10*l.*; steel angles, 9*l.* 10*s.*; steel joists, 9*l.* 15*s.*; heavy sections of steel rails, 9*l.* 10*s.*; fish plates, 13*l.*; black sheets, 13*l.* 10*s.*; and galvanised corrugated sheets (No. 24 gauge, in bundles), 19*l.* 5*s.*

THE SOCIETY OF ENGINEERS.—The Society of Engineers has arranged a visit to Wembley, to inspect the exhibition buildings in course of construction, for the afternoon of Wednesday, September 19. Full particulars may be obtained from the Secretary of the Society, 17, Victoria-street, S.W. 1.

MOTOR RAIL LOCOMOTIVE.—An inexpensive type of small locomotive has recently been constructed by Messrs. Lake and Elliot, of the Albion Works, Braintree, Essex. This is a four-wheeled machine, the frame of which is made of rolled sections upon which is mounted a Fordson tractor unit. The back axle is chain driven from the engine transmission, the front being also driven by chain, but from the back axle. A canopy is arranged over the whole. The reaper type of seat is retained for the driver, and the usual footplate, &c., are dispensed with. The little machine is said to be capable of moving trucks weighing 90 tons, so that it would prove serviceable for a great deal of work in yards and private sidings. Messrs. Lake and Elliot state that in their case it has replaced a secondhand steam locomotive at about a cost of one-sixth of the latter.

THE ROYAL DOCKYARD, COPENHAGEN.—The Government Commission appointed to investigate and report upon the conditions under which work is carried on at the Royal Dockyard, Copenhagen, has now practically finished its labours, and some definite proposals will soon be forthcoming. The Commission appears to be agreed that the dockyard is far from up-to-date;from a practical or business point of view, owing to a great extent to the detached position of the different workshops. In order to ensure an economical and rational system of working a concentration of all the workshops will be essential, and this will undoubtedly reduce the cost of working considerably, more especially with respect to labour. To carry out this reconstruction, however, will entail a substantial expenditure which is calculated at between 5,000,000 kr. and 6,000,000 kr. This, however, should prove a productive outlay. The decision as to the step to be taken rests with the Ministry, which will have to bring the matter before the Legislature.

COAL-MINING IN SPITZBERGEN.—At the present moment the prospects of the coal-mining industry of Spitzbergen do not appear to be particularly bright. Five concerns are now being worked, two Norwegian, a Swedish, a Dutch and an Anglo-Russian. In all 11 companies were formed, but six have either never been started or have had to cease work. The Anglo-Russian concern employs only some 25 men, and the annual production is some 10,000 tons. The Swedish mine employs about 350 men, and the annual production is about 100,000 tons. The Dutch mine employs about 200 men, but the output this year is very poor, being only about 30,000 tons. Of the two Norwegian concerns the "Advent Bay" Company employs some 350 men, and will this year ship about 125,000 tons; while the "King's Bay" concern employs more men during the summer than in the winter, the average number being about 300. This year's shipments by this concern are likely to amount to 385,000 tons, of which 245,000 tons will go to Norway.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—No feature of any importance falls to be recorded in connection with the Scottish steel trade. New business is still exceedingly scarce and price inducements fail to draw buyers. The reduction in the quotations for ship plates and angles has had little effect so far in the placing of fresh orders, but with shipbuilding affairs in such a condition as they are at present little business can be expected from that quarter in the meantime. The makers of structural steel continue actively employed but many of the black sheet makers report a quieter tone both in home and export consumption. The foreign trade overall is rather poor and the unsettled state of the world in general is almost wholly responsible. Until the Ruhr question is nearer a settlement little expansion in buying can be expected. The following are to-day's market quotations:—Boiler plates, 13*l.* per ton; ship plates, 10*l.* per ton; sections, 9*l.* 15*s.* per ton; and sheets, ¼ in. to ½ in., 12*l.* 10*s.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—The West of Scotland bar-iron trade is at present only a shadow of its former self and makers complain bitterly of the very poor demand now prevailing. Fresh orders are very scarce and business of almost any sort is extremely difficult to pick up, with the result that plant is far from being fully employed. The price of "Crown" bars is still 12*l.* per ton delivered Glasgow stations, but it is not so much the price asked by makers as the want of confidence on the part of consumers which is keeping back sales.

Scottish Pig-Iron Trade.—There has been little or no improvement in the demand for Scottish pig-iron during the past week. Existing contracts are responsible for most of to-day's deliveries as very few fresh contracts have been secured recently. Buyers are acting with great caution and orders being placed are for immediate or near date requirements as none are inclined to commit themselves any distance ahead. For hematite iron the demand is so slow even at 5*l.* 12*s.* 6*d.* delivered at the steel works that producers are willing to shade that price to secure any order amounting to a fair tonnage. Such lines are nevertheless few and far between. Foundry grades are moving slowly and there is a want of life all round. Current prices are called 5*l.* 7*s.* 6*d.* per ton for No. 1, and 5*l.* 2*s.* 6*d.* per ton for No. 3 iron, both on trucks at makers' yards. These prices mark a decline at half-a-crown per ton over the week.

Scottish Pig-Iron Shipments.—The shipments of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, August 11, amounted to 392 tons. Of that total 377 tons went foreign and 15 tons coastwise. For the corresponding week of last year the figures were 624 tons foreign and 134 tons coastwise, making a total of 758 tons.

TAXATION CHARTS.—Mr. Charles H. Tolley has prepared a new edition for 1923-24, of his very useful compilation of charts and tables relating to Income Tax, Super-tax, Corporation Profits Tax and other duties. This publication, which is put up in a very handy form of indexed folders, shows at a glance all the rates of payment, allowances and abatements for 1923–24 and for 19 previous years. There is a supplement with it which gives the amount of tax which is payable on all personal incomes. Messrs. Waterlow and Sons, Limited, of London Wall, are the publishers of the work, which is sold at a price of 2*s.* 6*d.* net.

TRADE MISSION TO RUSSIA.—We are informed by Becos Traders, Limited, Central-house, Kingsway, W.C.2, that after protracted negotiations on the part of their managing director, Mr. A. G. Marshall, they have arranged for the visit of a number of business men to Moscow where they anticipate being able to lay the foundation for future business and for the re-establishment of their organisation throughout Soviet territory. The members of the mission are: Mr. F. L. Baldwin, Director of Archibald Kenrick and Sons, Limited, West, Bromwich; Sir Charles Wright, Managing Director of Baldwins, Limited, and of other concerns; Mr. John Denny, Managing Director of Wm. Denny and Brothers, Limited; Mr. J. J. Carter, Managing Director of Crossley Brothers, Limited; Major Barley, representing Nobel Industries, Limited; Mr. A. G. Marshall, Mr. N. Neville, Mr. S. W. Reeve, Mr. J. Wardroper, managing directors of Becos Traders, Limited.

ELECTRIC FURNACES IN SHANGHAI.—Owing to the energetic policy of Mr. T. H. U. Aldridge, the engineer and manager of the Shanghai Municipal Electricity Department, the City of Shanghai has now a greater annual consumption of electricity even than Manchester, the largest British municipal undertaking, and a load factor twice as great as our own great industrial area. Consequently electricity in Shanghai is remarkably cheap, in spite of the fact that it is all generated by steam plant. Mr. L. W. Hoyt, the American Trade Commissioner has contributed an article to the "Far Eastern Review" pointing out the great possibilities of electric furnaces in the city, and the hint might be taken to heart by British makers of such furnaces. Power is available to manufacturers in the city at less than 0·6 pence per k.w.h., which is less than that prevailing in Milwaukee, the centre of the American electric steel casting business. According to Mr. Hoyt the cost of electric power in America averages one-third of the total cost of steel in the ladle. The Shanghai supply is 3-phase current at 50 cycles.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—Exports of coal as cargo from South Wales in July to foreign countries amounted to 2,567,299 tons compared with 2,561,268 tons in June, a reduction of but 6,031 tons. The July shipments represented an average of 98,510 tons per working day or 250 tons per day less than in June, but were 8,100 tons per day less than in May. Of the July exports 1,438,153 tons were despatched from Cardiff, 485,911 tons from Newport, 317,675 tons from Swansea, 262,079 tons from Port Talbot and 57,450 tons from Llanelly. The direction of the exports in July of this and last year is shown below:—

South Wales to—	July, 1922. Tons.	July, 1923. Tons.
France	613,746	1,092,878
Italy	325,330	360,698
South America	211,075	353,791
Spain	158,602	145,870
Portugal	74,964	74,988
Greece	50,145	10,681
British coaling depots ...	117,584	214,729
U.S.A.	25,655	—
Canada	12,258	24,150
Other countries	318,163	283,473
Totals	1,907,522	2,561,268

It will be seen that compared with a year ago the trade showed an increase of 653,746 tons, of which French business was improved to the extent of 479,132 tons; Italian, 35,368 tons; South American, 142,716 tons; British coaling depots, 97,145 tons, and Canadian trade by 11,892 tons. On the other hand Spanish business fell off by 12,732 tons; Greek by 39,464 tons, United States by 25,655 tons and that with other countries by 34,680 tons. During the past week the demand for coal has been comparatively quiet. Some of the collieries are, however, comfortably placed up till the end of the month, but there are also a number requiring business. In the circumstances, prices are irregular and dependent on individual circumstances with the tendency on balance towards lower levels. Best Admiralty large is obtainable at 30*s.* with seconds round 29*s.*, and the leading Monmouthshires from 27*s.* to 29*s.*, while dry large is also available at 28*s.* to 29*s.* Smalls of most classes are in plentiful supply with the best steams worth no more than 22*s.* and the cheaper descriptions from 14*s.* to 18*s.* The demand for coke has eased off, and furnace sorts are now obtainable for export at 47*s.* 6*d.* with foundry from 50*s.* to 55*s.* Patent fuel continues in little demand with prices from 30*s.* to 34*s.*

Iron and Steel.—During the past week a large contract, amounting to several hundred thousand boxes, which will be distributed over various tin plate makers, was placed in South Wales, and this coupled with the restricted output consequent on the week's annual holiday of the workers has steadied the market. In fact the outlook is more favourable than it has been for some time past. Inquiries too are more general especially for early shipment and prices are steady on the basis of 23*s.* 1½*d.* The French sardine preserving industry, it is stated, is threatened with extinction owing to the small catches of fish. Should this prove correct the effect will be reflected on the French imports of tinplates.

INSTITUTION OF CIVIL ENGINEERS OF IRELAND.—The proceedings of this Institution, vols. xlvii and xlviii, bound together, are now available. They deal with the eighty-fifth and eighty-sixth sessions, from November, 1920, to May, 1922, and certain papers on "Wave Impulses through Liquids," by Professor Lilly; on "The Salvage of the Dredger Silurus," by Mr. A. D. Delay, with others of interest.

BRITISH IRON AND STEEL PRODUCTION.—The National Federation of Iron and Steel Manufacturers state that the production of pig-iron in July amounted to 655,100 tons compared with 692,900 tons in June and 399,100 tons in July, 1922. The furnaces in blast at the end of the month numbered 206, a decrease of 16 during the month. The output of steel ingots and castings amounted to 624,300 tons compared with 767,700 tons in June and 473,100 tons in July, 1922.

PERSONAL.—We are informed that Messrs' Smith's oil burning system has been taken over by Messrs. Swinney Brothers Limited, Morpeth. This step has been necessitated by the development of the Smith's Dock Company who require all the room at their North Shields yards for other purposes. Messrs. Swinney Brothers have for some time done most of the manufacturing in connection with Messrs. Smith's oil fuel system and Mr. H. A. Thompson of the latter firm is joining Messrs. Swinney as director and general manager.

UNITED STATES BUSINESS CONDITIONS.—The representative in London of the Irving Bank-Columbia Trust Company, New York, has been advised by cable from headquarters that the retail, wholesale and jobbing trades are irregular. June wool consumption amounted to 44,700,000 lb.; July pig-iron output totalled 3,680,000 tons; July failures numbered 1,406, and the capital involved was 36,584,000 dols. The silk market is dull, and cotton conditions are worse than expected since the last report. United States steel earnings for the second quarter were 47,858,000 dols. as against 27,287,000 dols. in the corresponding period of last year. New railroad securities issued in July amounted to 41,513,000 dols.; new industrials to 109,129,000 dols. and new public utilities securities to 40,658,000 dols.

DRY GAS-CLEANING PLANT AT PALMERS SHIPBUILDING AND IRON COMPANY'S WORKS, JARROW-ON-TYNE.

CONSTRUCTED BY FRASER AND CHALMERS ENGINEERING WORKS, ERITH.

(*For Description, see Page* 195).

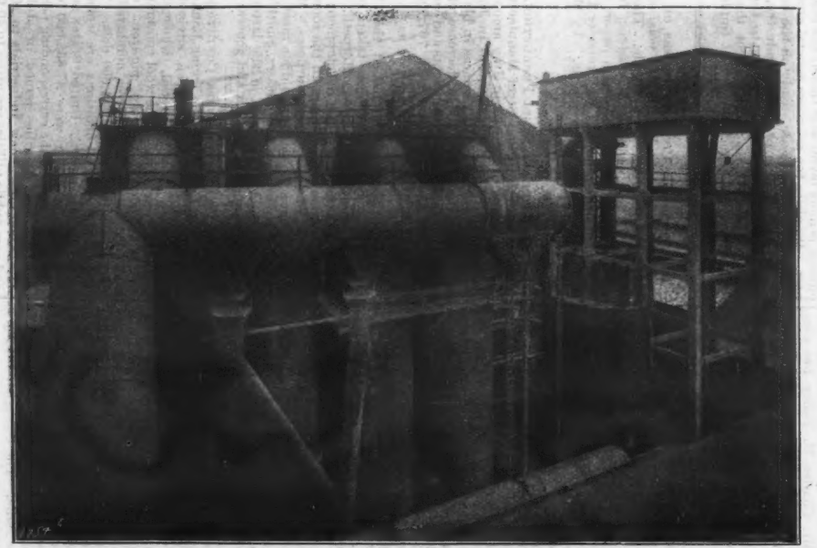


FIG. 9. CRUDE GAS MAIN, COOLERS AND FINAL COOLER.

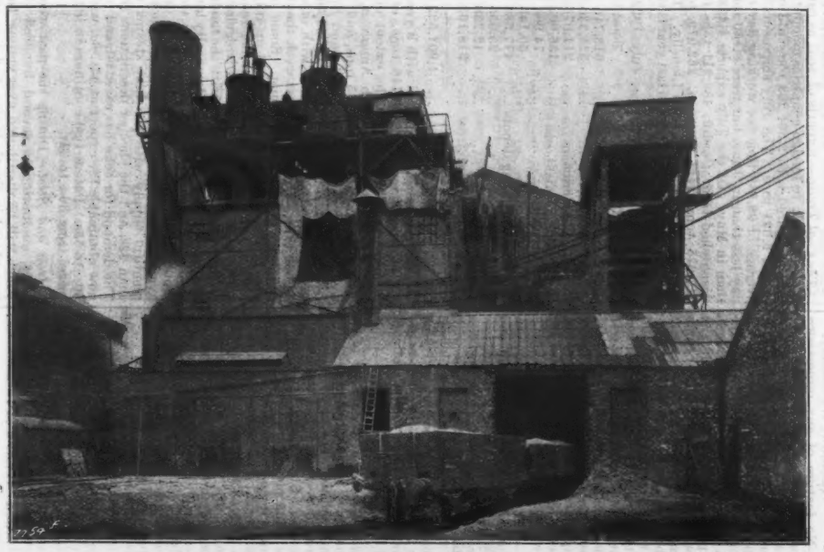


FIG. 10. FILTER-HOUSE SHOWING DUST REMOVAL.

FIG. 11. TOP FLOOR OF FILTER HOUSE.

FIG. 12. FIRST FLOOR OF FILTER HOUSE.

Fig. 11. Top Floor of Filter House.

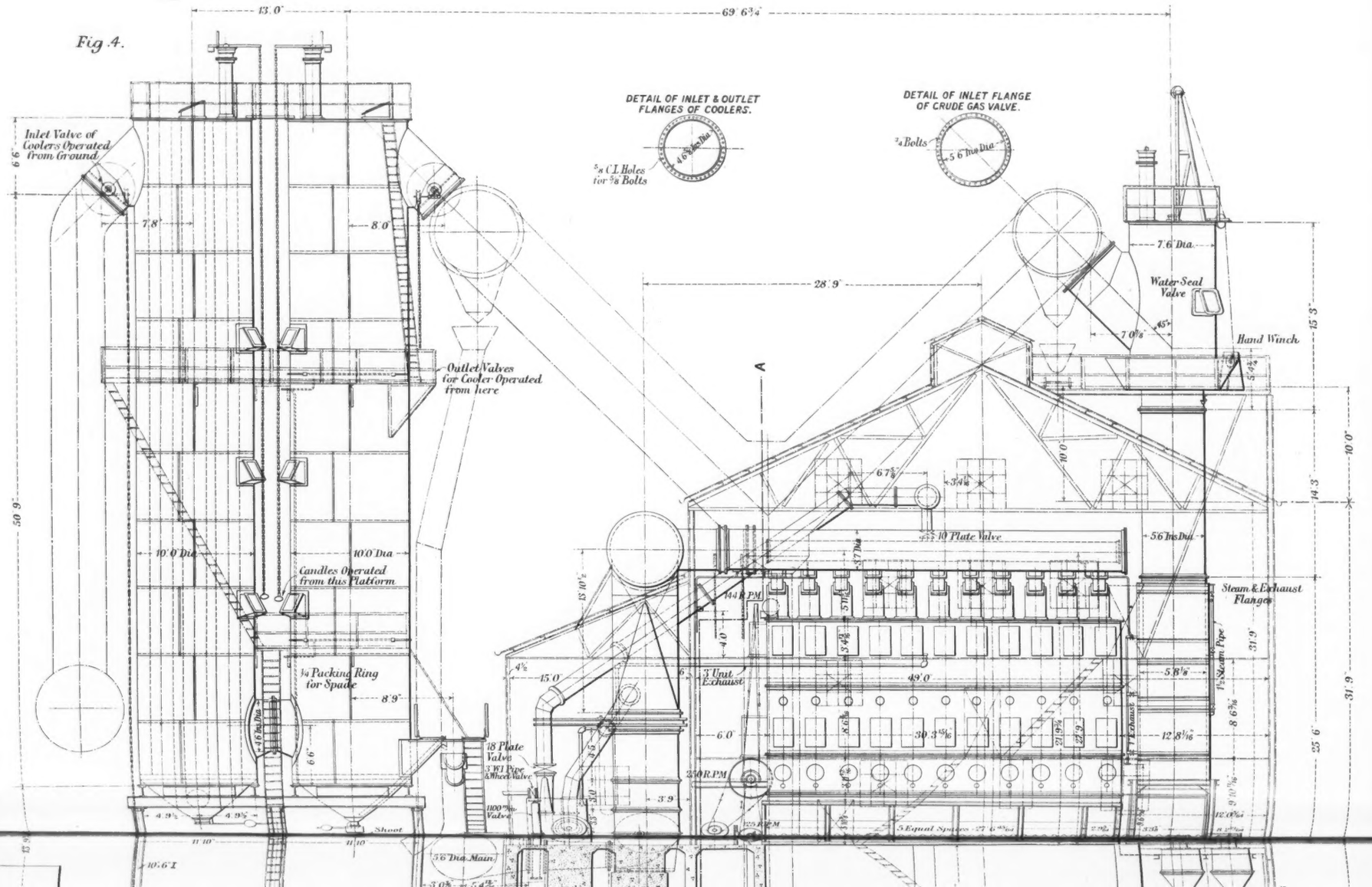
Fig. 12. First Floor of Filter House.

DRY GAS-CLEANING PLANT AT PALMERS SHIPBUILDING AND IRON COMPANY'S WORKS, JARROW-ON-TYNE.

CONSTRUCTED BY FRASER AND CHALMERS ENGINEERING WORKS, ERITH.

(*For Description, see Page* 195.)

Fig. 4.



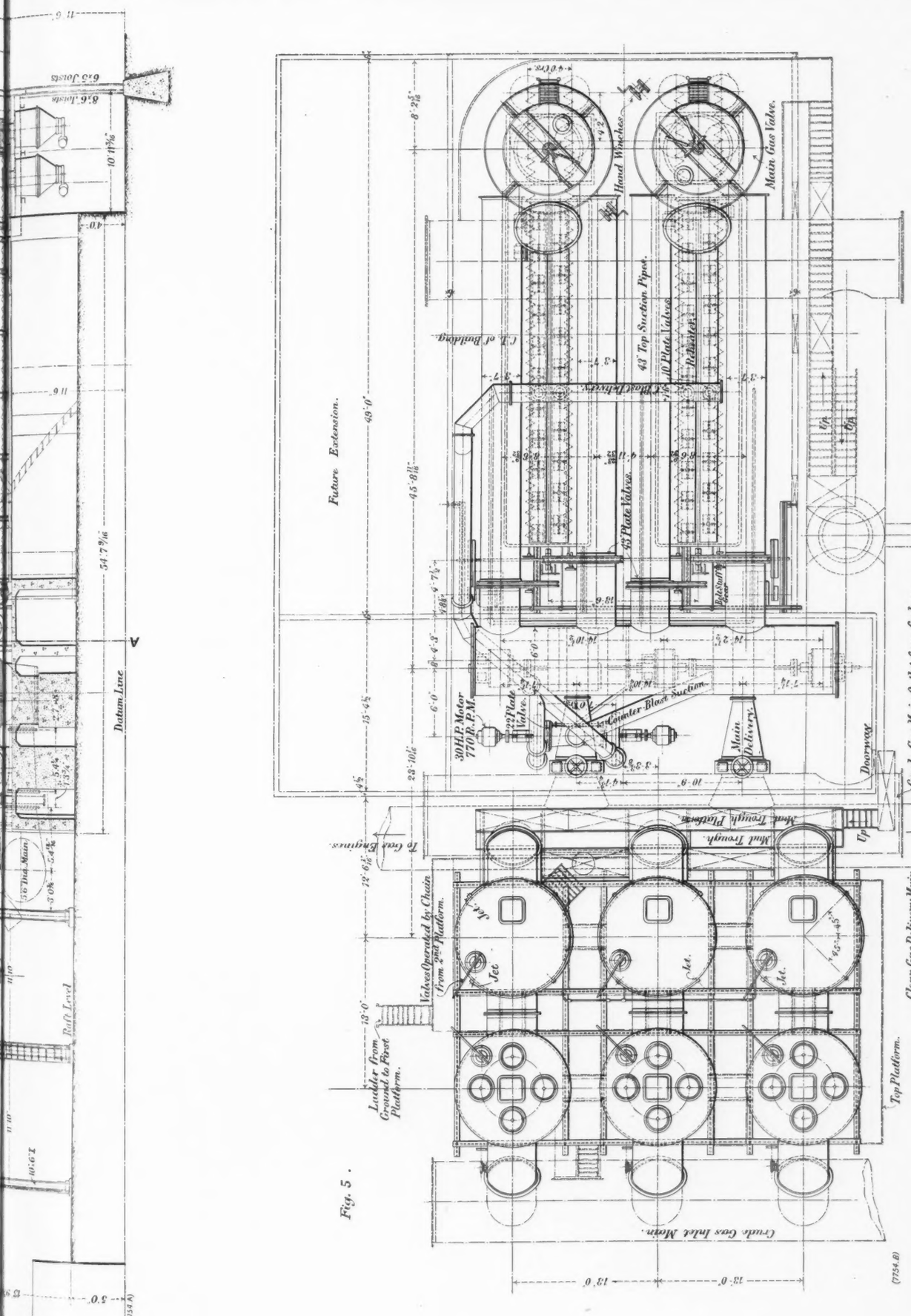

Future Extension.
Hand Winches
Main Gas Valve.
43" Top Suction Pipes.
40 Plate Valves
Reheaters
43" Plate Valves.
Datum Line.
A
30 H.P. Motor
770 R.P.M.
22" Plate Valve
32" Counter-Blast Suction
Main Delivery.
Doorway
Crude Gas Main Outlet from Coolers.
Mud Trough
Steel Trough Platform
To Gas Engines.
Up
Valves Operated by Chain from 2nd Platform.
Jet
Clean Gas Delivery Main to Stoves.
Ladder from Ground to First Platform.
Top Platform.
Crude Gas Inlet Main.
13' 0"
(7754.B)

Fig. 5.

ENGINEERING.

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ENGINEERING.

FRIDAY, AUGUST 17, 1923.

THE CREATIVE MIND.

"THE man who can form an ackerate judgment of an animal, can form an ackerate judgment of anything," observed Mr. Tony Weller when appointing two fellow coachmen as umpires to keep a wary eye on Mr. Solomon Pell. If the word animal be replaced by literary style the precept in question is widely held amongst the ready writers, who have assumed the task of guiding public opinion on all matters, including delicate questions of foreign policy, the relative merits of different systems of wireless telegraphy, and the intrinsic value of modern methods of medical prophylaxis. Another claim persistently advanced by this school is that there is no scope for really creative thought outside of literature and art. It is pointed out for example that if Shakespeare had never existed, we should not have had the character of Hamlet, whilst had Newton failed us, the only drawback would, it is claimed, have been a delay of a few years in the formulation of the doctrine of universal gravitation, since it is asserted that other investigators must ultimately have devised a substantially identical theory. It will be seen that on this view, it is the uniqueness of a product, which alone entitles it to the status of a creation, and it is assumed that all mechanical and mathematical discoveries would ultimately have been contrived by others had their actual originators been wanting. There may be a certain modicum of truth in this latter contention, but the fact that we have still existing amongst us communities little advanced in culture beyond the stone age throws doubt on its universal validity, and this doubt is confirmed by the failure of generations of mathematicians to discover the "truly wonderful proof" of Fermat's famous theorem, for which that highly original thinker was unable to find room on the margin of the book he was annotating.

Leaving this subsidiary assumption aside, uniqueness constitutes but a poor criterion of creative ability. Clerk Maxwell expended some of his surplus energy in penning quite clever occasional verse, which if not written by him would never have been written at all, and possessed therefore this property of uniqueness. Hence if the standard suggested were sound, his creative genius should be estimated by these diversions rather than by his extraordinary researches into electrical theory, of which one outcome has been wireless telegraphy, and another the doctrine of relativity. This example should of itself suffice to show that the proposed criterion of creative power is essentially a false one. The genius that invented the bow and arrow had a creative mind, even though successors of very moderate ability may have produced very much better weapons than the original model.

Indeed the standard suggested really involves the claim that it is the style which is important and not the thought. That it matters little what is said so long as it is said smartly, is no doubt a maxim which has been most successfully exploited during the past twenty-five years by our popular publicists, and in particular by that prosperous writer of comedies, who has been acclaimed by his admirers as the man who has relieved the middle classes of the necessity of thinking for themselves. Actually, of course, he and his fellows have contributed nothing new to human thought. Indeed, even the most striking passages in Samuel Butler's notebook are merely old thoughts redressed. An Einstein or a Darwin must, in short, be equipped with a much higher grade of intellect than suffices to drive a ready pen, and indeed many really original thinkers have been deficient in the art of expression and suffered accordingly. Nevertheless, it is not in the Arts alone that a characteristic style may be displayed. Newton's solutions to the problems set by Bernoulli were sent in anonymously, but the recipient recognised the master hand at once "as if the lion by his claw." It would be well were it ever thus, but really novel and fertile ideas never spring from the head of their creators as Minerva did, from that of Jove fully armed and equipped. The process of parturition is much more normal. There is first a period of gestation, often greatly prolonged, and even so the new concept is often but a weakling at birth, becoming strong only as the result of prolonged care and attention.

Many of our popular publicists have very curious ideas as to how new thoughts become the common property of mankind. In one recent instance the Copernican theory was claimed for Leonardo da Vinci on the ground that the suggestion of a Heliocentric cosmos is to be found in his writings, and the further claim was made that the poet knows all truth intuitively and does not require the guidance of experiment or experience.

Of course, even a rudimentary knowledge of history would have demonstrated the absurdity of this claim. It was the poets who, trusting to their intuitions, imagined the myth of the Golden Age from which mankind had fallen into hardship and misery, whilst it is the anthropologist who has made us realise from what depths of savagery, poverty and danger mankind has been toilsomely dragged by the efforts of successive individual men of genius. Darwin has related the shock with which he at length realised that at no distant date, geologically speaking, his ancestors were living in a state of culture comparable with that of the naked savages of Tierra del Fuego.

Here, at least, the ready writer's intuition has proved sadly at a discount, and there is, of course, the added difficulty that the intuitions of different writers not infrequently take flatly contradictory directions. The claim for this supremacy of the intuitive faculty is, moreover, an old one, dating back at least to Plato and Socrates, whose doctrine that the mind could arrive at truth by a process of pure reflection, uncontrolled by experiment or experience, has had fatal attractions for the fluent of every succeeding generation.

At Oxford, for example, is has been customary to demand from the undergraduates essays on certain set subjects. In the case of the average man the requirement has been wholly beneficial, but according to one authority, the result is far from satisfactory in other cases. Certain men, in short, learning that they can write readably on any subject never take the trouble then or thereafter to master any one. By them observation is replaced by hypotheses, and for such men the sole test of the truth of an assertion is its plausibility.

This view was, of course, that prevalent in the middle ages and was also largely held in antiquity.

So long as it prevailed real progress was slow. The atomic theory of Democritus had no more to recommend it than had the opposing doctrine of Anaxagoras; and, indeed, it is noteworthy that on the revival of learning it was this second view which led to results of the most immediate interest and importance. The application of mathematics to physics which led to such a wide expansion of our concepts of the universe was at the outset based wholly on the doctrine of continuity, and the atomic theory only began to come to its own with the advent of Dalton. To-day, as we know, it or an analogous concept has even invaded pure mathematics, the characteristic feature of which during the past forty years has been the arithmetisation of analysis.

Of course, intuition has its value, and when guided by adequate knowledge constitutes the distinction between a class A and a class B mind. "We are poets" was the claim made at a mathematical congress many years ago, and it is the artistic faculty of recognising and selecting amongst almost innumerable data those of prime significance which constitutes the distinction between the scientific thinker and the mere "researcher" who does the hodman's work of recording observations and measurements. Indeed, some of those who have made really serious contributions to the advance of scientific thought have not themselves been anything exceptional as either observers or experimentalists, and the converse also holds. Many instances could be adduced in support of this contention, and it is in fact generally recognised that many more men are fitted to contribute to scientific data than to advance scientific thought.

The great engineer and the great organiser must also be gifted with intuition. It is they who have to bridge the gap between a laboratory experiment and its practical applications. The gulf between the two is vast, and to free it, other qualities than mere mental acuteness are demanded, of which perhaps the most conspicuous is courage. Pepys tells in his Diary of some acquaintance who ventured and lost 20,000*l.* in trying to improve methods of coal winning, and to come to more modern times, more than one fortune was lost in practicalising the ammonia soda process before success was finally attained. This instance is in itself sufficient to show the lack of foundation for the statement of a well-known Oxford professor to the effect that a chemist might write on a half sheet of note paper a formula which would keep a whole community in affluence. Neither carbonate of soda, nor sulphuric acid can, however, be produced by means of a mere paper formula any more than a steam turbine can be constructed by hitching a table of the properties of steam to a prime motion shaft. Both the formula and the table may be of great potential value, but actually to realise this, much has to be risked and, in general, much lost before final success is achieved.

INTERNATIONAL SHIPPING REGULATIONS.

We publish on page 217 of the present issue a paper read on Tuesday last at the meeting of Swedish Naval Architects, at Gothenburg by Sir Westcott Abell, Chief Ship Surveyor to Lloyd's Register of Shipping, on the subject of International Regulations for various phases of the shipping industry—a subject of supreme interest to all sea-faring nations. The paper gives in an interesting manner a summary of the work already accomplished, and shadows forth the lines upon which still further developments may be expected to follow. Credit for the progress made must be largely ascribed to the Chamber of Shipping of the United Kingdom and the Liverpool Steam Ship Owners' Association. The International Conference of Shipowners held in London in November, 1921, was arranged by them, and although the world war was then over, and the desirability of establishing International regulations for the government of the shipping industry was becoming more and more recognised, it required no small amount of courage to call upon the representatives of all countries to assemble together, to lay their cards upon the table, and to endeavour to frame such regulations as would give fair play to each and every country, and afterwards to promise to approach their respective governments with a view to making such regulations a part of the law of their own country. The courageous course thus taken has, however, been amply justified, as shown by the very excellent results of the three International Committees more especially referred to by Sir Westcott Abell.

The work of that Committee which dealt with the question of load-lines for cargo vessels was perhaps the most difficult. They took for their basis the proposals of the Board of Trade Load-line Committee of 1915, which followed the great convention held in London after the Titanic disaster, and considered the effect which the adoption of those proposals would have upon the freeboard regulations at present in force in the various countries represented. It will be observed, upon examination of the experience obtained since detailed freeboard regulations were first embodied, that special favour had to some extent been shown to certain types of ship as compared with others, and while by the adoption of the Board of Trade Committee's proposals the scales of justice would be more equally balanced, this would involve some increase of freeboard in the ships which had previously been favoured. Other points dealt with included (*a*) the reductions of freeboard permissible for certain relatively small areas, such as those already given for trade in the Indian Ocean and for other parts of the world enjoying similar climatic conditions, (*b*) the freeboards of sailing ships in relation to those of steam vessels, and (*c*) the determination of a grade of comparison between the freeboards of sailing and steam or motor vessels and the basis of such comparison, which it was suggested should be defined upon a relation between displacement and horse-power.

The Committee which dealt with deck cargoes was less hampered by tradition, for in the first instance they found that their deliberations must almost necessarily be based upon consideration of the experience of the Scandinavian nations (particularly the Norwegians) who had perhaps naturally had the bulk of this trade. Hitherto the British regulations had practically only provided for the *security* of wood goods carried on deck, but regulations have now been finally agreed upon for the carriage of light wood goods on deck, for the carriage of heavy wood goods on deck, and for the allowance to be made in freeboard for the carriage of such deck cargoes, based upon a comparison of the reduction to be allowed for such deck cargoes, securely stowed, in relation to the reduction allowed for a similar fully enclosed steel superstructure.

The Committee dealing with the load-line of passenger vessels were chiefly concerned with the question of bulkhead sub-division, for the purpose of ensuring a larger measure of protection for the passengers carried, regard being paid to the size of ship, the number of passengers carried, and the differentiation to be made as the passenger accommodation grew at the expense of cargo-carrying. The recommendations of the Convention which followed the Titanic disaster had not paid sufficient regard to the economic conditions of overseas passenger trade, and a large amount of work has been done with a view to obtaining a reasonable balance between safety and economic requirements. The International Committee has drawn broad conclusions and made certain other recommendations in an endeavour to obtain greater ease of determination, while at the same time ensuring accuracy of comparative treatment.

The reports of these Committees are in the hands of the British Board of Trade (together with those of the Committees on Life-saving Appliances and Wireless Telegraphy, which have already been examined and to some extent adopted), and it is hoped that with the knowledge that the regulations suggested are put forward by unanimous resolution of the shipowning representatives of the various countries represented, they will be favourably received and to a large extent adopted. What, however, strikes us as the main feature of the whole matter is that the shipping industry (and it must be remembered that all seas are one salt water), is attempting in the interests of all sea traders and users, whether for passenger or cargo purposes, to make regulations which will give fair play to all, and that the acceptance of these regulations by the nations which have taken part in the work is a long step towards greater mutual understanding and greater world stability.

HYDRO-ELECTRIC DEVELOPMENTS IN CALIFORNIA.

In the State of California, as in the coal-less belt of the Dominion of Canada, rapid settlement, growth of population and the intensive development of industry have precipitated a severe power shortage probably without parallel in the history of commercial and social economics. The whole of the territory lying west of the Cascade and Sierra Nevada mountain ranges, from the Canadian to the Mexican frontiers, is more or less affected, although the situation is most acute in California from the circumstance that development is more advanced. The situation has become so critical as to have compelled the various corporations, serving the western states with electrical energy to elaborate a ten-year construction programme, the fulfilment of which, it is anticipated, will permit supply overtaking demand by 1930. Incidentally, the crisis has been responsible for a movement which, when fully consummated, will bring about the complete electrification of the whole of the North American Pacific Coast from San Diego to Vancouver, and in which American and Canadian enterprise will co-operate.

This construction programme is involving a financial commitment of 200,000,000*l.*, of which one-half, or 100,000,000*l.*, is to be expended in the State of California alone. Among the items involved may be mentioned 8,400,000*l.* on new power houses and plant, 7,500,000*l.* on line transformers and other transmission equipment, 7,000,000*l.* on sub-station installations exclusive of buildings, and over 4,000,000*l.* on meters.

At the present moment 1,760,000 h.p., generated by water, coal, oil and natural gas, are being devoted to the production of 1,246,000 kw. of electrical energy. To-day 83 per cent. of the residences in the State are wired for electric lighting, as compared with less than 40 per cent. for the whole of the United States. In 1920, 1,470,000 acres of land demanding irrigation, were being watered by electrically-driven pumps, the aggregate horse-power of the motors engaged in this service exceeding 500,000, absorbing more than 17 per cent. of the total power generated. During 1921 the rate for this energy averaged only 1·42 cents, say 0·7*d.*, or ¾*d.* per kilowatt-hour, as compared with 2·17 cents, or about 1·08*d.* for the whole country. As the result of this attractive rate the consumption per head throughout California for the year was 1,085 units, as against 372 units forming the average for the United States.

The expansion of the hydro-electric power industry in the State has been remarkable. In 1901 the installed capacity did not exceed 30,000 h.p. According to the U.S. Geological Survey statistics, during the year ending December 31, 1922, Californian production totalled 3,770,376,000 kw.-hours, New York State coming second with 2,953,209,000 kw.-hours, while the total production by water-power for all the States in the Union stood at 17,213,217,000 kw.-hours. During the nine years, 1911 to 1920, the increase in total production rose from 1,402,000,000 kw.-hours to 3,617,600,000 kw.-hours, or approximately 150 per cent., representing an average increase of 11·1 per cent. per annum. During this period hydro-electric production rose from 1,068,000,000 kw.-hours to 2,493,000,000 kw.-hours, or approximately 134 per cent., while that generated by steam rose from 334,000,000 kw.-hours to 1,124,600,000 kw.-hours, or approximately 237 per cent., which compounded annually, is equivalent to 14·4 per cent.

Sustained industrial development and settlement have been responsible for this hydro-electric expansion, but these factors in turn have been influenced by the availability of cheap power. During the census period, 1910–20, California advanced from twelfth to eighth position among the 49 States comprising the Union in regard to

population, with an increase of 1,049,312. It ranks eighth in the value of its manufactured products, fifth in the variety of its industries, fourth in the value of its agricultural products, which now have an annual value exceeding 120,000,000*l.*, and first in the output of minerals with nearly 50,000,000*l.* per annum. But it is the agricultural development which is the most striking, due, in the main, to the reclamation of the semi-arid areas through irrigation by electrical pumping.

If the prosperity of the State is to be maintained further electric energy must be forthcoming. It is practically deficient in coal, and although oil is abundant, the State alternating with Oklahoma as the largest producer of petroleum, supply is far below demand. In June, 1914, oil shipments averaged 300,000 barrels a day, and this was so far below local consumption as to enable gross stocks, aggregating 60,000,000 barrels, to be accumulated. In that year oil at the wells averaged 35 cents., or a trifle less than 1*s.* 6*d.* per barrel. Between the summer of 1914 and the end of 1920—the war period—shipments fluctuated widely, ranging from the minimum of 200,000 barrels a day in December, 1915, to the maximum of 350,000 barrels a day at the end of 1920. During this period, however, stocks on hand shrank to 20,000,000 barrels, due to the fall in production and the rise in domestic consumption, while the price at the wells rose to 1·60 dols., or 6*s.* 8*d.* per barrel.

The oil situation was somewhat eased in 1920 by the discovery of the Elk Hill and Huntingdon Beach fields, but the respite was brief. Californian oil production rose to 114,600,000 barrels in 1921, but the consumption in the State rose to 122,600,000 barrels, leaving an adverse balance of 8,000,000 barrels on the year's operations. This had to be redeemed from stocks which stood only at 32,000,000 barrels, while the price to the consumer advanced to about 2 dols., or 8*s.* 4*d.* per barrel. Liquid fuel at this figure renders steam-generated electricity too prohibitive to encourage industrial expansion, especially as this cost factor has a pronounced upward trend. Consequently, the steam plants maintained in the cities by the generating companies are employed as reserves, for emergency use, and to take care of the peak loads.

The uncertainty of the oil situation brought matters to a climax in 1920. Oil stocks had shrunk to 20,000,000 barrels, while there was a deficiency of electric energy to the extent of 100,000 h.p. The loss to the State was estimated to run into millions sterling. Building operations were suspended; the reclamation of land was arrested; while there was a marked diminution in the manufacturing industries. The situation became so critical as to compel the intervention of the Railroad Commission with drastic regulations concerning the distribution of electric energy, petroleum and natural gas throughout the State.

It was this official action which persuaded all the electric power companies to interconnect their systems to permit the diversion of electric energy from one district to another according to demand, thus converting the various organisations into one homogeneous entity for distribution. The whole of the electric energy is furnished by 20 companies and corporations, the power being raised by water, oil and natural gas. While many of the contributors of energy are relatively small local undertakings, others are of impressive proportions, generating the power at considerable distances from the consuming markets.

The largest individual generating organisation is the Pacific Gas and Electric Company, with an installed capacity of 441,200 kw. Then there is the Southern California Edison Company, with 299,800 kw.; the San Joaquin Light and Power Corporation, with 141,500 k.v.a.; the Great Western Power Company, with 140,400 kw.; the Municipality of Los Angeles, 64,450 kw.; and the Southern Sierras Power Company, with 48,675 kw.

Each of these undertakings has selected and developed its individual hydraulic field among the Cascades and the Sierra Nevadas, and has laid down long-distance trunk transmission lines for the distribution of the power. The Pacific Gas and Electric Company has probably the most widely spread network of power houses due to the fact that it is really an amalgamation of a number of other companies. Its greatest installation is on the Pit River, the first units of which were completed last year, together with the 300 miles of transmission lines to San Francisco—202 miles at 200,000 volts, then stepped down to 110,000 volts for feeding into the general high-tension supply system. It has other immense developments near Chico, at Colgate, Lake Spaulding, Halsey, Wise, Electra and Stanislaus, its operations being conducted over an area of 54,000 square miles, or more than England and Wales combined. Its transmission and distribution network comprise 47,100 miles of cables and wires; the connected load exceeds 1,050,000 h.p.; while during 1922 its production totalled 1,120,811,689 kw.-hours by water power. Agricultural motors aggregating 150,000 h.p., and mining, electric railway, industrial and other motors totalling 455,400 h.p., are directly connected to this system, which also furnishes current to 52,500 street lamps and 5,234,600 incandescent electric lamps.

The Great Western Power Company has turned to the Feather River for its hydraulic power, sending the electric energy there generated over 180 miles of trunk line at a pressure of 165,000 volts. Big Creek is the hydraulic field exploited by the Southern California Edison Company, the power being sent at 150,000 volts over a line 250 miles long, to serve Los Angeles, but this pressure is to be raised in the near future to 232,000 volts. The San Joaquin Light and Power Corporation is established in the Fresno country, its operations being confined for the most part to the supply of energy throughout the raisin-growing districts in the San Joaquin Valley. The Los Angeles authorities draw energy from the head of water of their public supply brought from the Mojave Desert, the two power stations, established at San Francisquito, each developing 28,000 kw.

The Southern Sierras Power Company has exploited the Bishop Creek hydraulic field on the eastern borders of the State. This scheme was inaugurated essentially for the supply of power to the Tonopah and Goldfield mining districts of Nevada, at the northern end of Death Valley, but the demand for power from the south resulted in the construction of a direct transmission line to San Bernardino: thence on to Yuma, Arizona, and the Mexican border, where the power is picked up by a Mexican company for local distribution in Mexico. The Southern Sierras Power Company is remarkable for operating the two longest transmission lines in the world, power being delivered to Yuma over two lines, 462 miles and 543 miles in length respectively, the pressure, designed for 150,000 volts, being at present 100,000 volts. These are actual transmission distances.

As the result of the physical interconnection of the various systems a continuous supply of power is assured throughout a zone of some 600 miles around San Francisco. The network which has thus been woven extends from the Mexican border to the Oregon State line and beyond, the interconnecting line with the Pacific Gas and Electric Company near Shasta, being carried north to the inter-State boundary and thence into Oregon. A similar interconnecting system has been established farther to the north, the hydro-electric companies operating in British Columbia having interswitching with those established in the State of Washington, so that Canadian hydro-electricity is transmitted to a considerable distance south of the International Boundary. It can be drawn upon, when desired, to feed the electrified mountain division of the Chicago, Milwaukee and St. Paul Transcontinental Railway. The closing of the gaps in the lines radiating through the States of Oregon and Washington will interconnect the zones of California and southern British Columbia, and provide a continuous network of lines reaching from the Mexican border to the numerous power houses around Vancouver, the most extensive, complete and comprehensive electrical distribution scheme ever contemplated.

The contructional programmes which have been elaborated by the various Californian undertakings are of a comprehensive character. According to the Government surveys the potential water power of the State is 7,818,000 maximum, and 3,424,000 minimum, based upon the utilisation of 90 per cent. of the stream flow and a plant efficiency of 75 per cent. It is estimated that engineering development for water conservation will enable 5,500,000 h.p. to be turned to account. Of this available total about 1,000,000 h.p. are already being exploited. In determining their construction programmes the companies have based their estimates upon the growth of the demand during the past ten years, and as this gives every indication of being sustained, it is felt that the method of computation is justifiable, although there is a lurking fear that it may prove to be too conservative.

On the basis of this calculation the demand by 1930 will attain 10,356,000,000 kw.-hours for the year, with a probable average load, based upon a load factor of 60 per cent., of 1,182,000 kw., and a peak of 1,970,000 kw. To assure this supply it is incumbent for the supply companies to turn primarily to water power, because, under ruling conditions concerning fuel prices, it will be impossible to carry steam generation beyond a certain limit. It is imperative that the price of current, on the basis of a 65 per cent. load factor at load centres, should not exceed 0·4*d.* per kilowatt-hour, which figure is possible of fulfilment only by hydro-electric energy. The cost of generation based upon the ruling figures, is assumed to be 50*l.* per kilowatt from water diversion to sub-station, plus 30*l.* for distribution to consumer, or 80*l.* per kilowatt all told, but exclusive of the necessary expenditure upon the consumer's premises. Close study of the problem reveals that to produce energy by steam power at the foregoing price per kilowatt-hour it would be necessary to purchase liquid fuel at 47·5*d.* per barrel, coal at 13*s.* per ton, or natural gas at 0·08*d.* per 1,000 cub. ft.—figures which are quite impracticable to-day. Furthermore, whereas steam production is affected by fluctuating fuel charges, the cost of hydro-electric energy remains practically stationary, the fixed charges on capital expenditure being the main factor. In these circumstances it is generally considered that steam station development will not be carried to a point exceeding 25 per cent. of the anticipated peak loads.

In accordance with the constructional programme the Southern California Edison Company has brought the first three power units of its Big Creek development to an installed capacity of 112,500 kw., while the designs for raising this output to the maximum of 750,000 kw. from this rich field are completed. The Great Western Power Company has the first two of its chain of seven power houses established upon the Feather River at Caribou and Las Plumas respectively, in service, delivering 109,400 kw., the sites for the outstanding five power houses along the river for the successive use of the water having been tentatively decided. The San Joaquin Light and Power Corporation has turned to the King River for its further supplies, and has completed the surveys for the development which is to yield 470,000 h.p. At the same time it has laid down the first unit of the Button Willow steam plant developing 25,000 kw., using natural gas pumped from the Bakersfield oilfields as fuel. When this station is completed it will absorb 80,000,000 cub. ft. of this petroleum by-product during the 24 hours.

The Pacific Gas and Electric Company brought the first unit of its comprehensive Pit River project into operation in October last, and this may be said to represent its initial contribution to its contemporary ten-year construction programme. Three plants are comprised in this first unit, the Pit No. 1 with its two 35,000 k.v.a. turbo-generators, the second largest in the world, and the two stations on Hat Creek, each having a single turbo-generator of 12,500 k.v.a. The power of the Pit No. 1 units was governed by the necessity to determine the most economical unit for charging the 220,000 volts transmission line. The current generated in the two Hat Creek plants is transmitted to the large power station, stepped down to 11,000 volts, and then fed to the bus-bars to which the current is brought from the 35,000-k.v.a. generators, to be stepped up to the high pressure for transmission over the 202 miles to the Vaca-Dixon sub-station near Sacramento. Here it is stepped down to 110,000 volts, to be fed into the high-tension transmitting system carrying supply to San Francisco from the De Sabla, Colgate, Spaulding, Drum, Electra, Stanislaus and other power stations. Although the Pit River line is designed to carry the

current at 220,000 volts the potential employed at the moment is 175,000 volts, which ranks as the highest working transmission pressure in the world. The reduced potential is due to the researches and experiments relative to the insulators being incomplete; when they are finished the present insulators, of a temporary character, will be replaced, and the transmission pressure raised to the designed 220,000 volts.

The completion of this initial contribution has increased the supply of the corporation by 95,000 k.v.a. In the course of the succeeding 50 miles flow of the Pit River four additional stations are to be built, the capacities of which, as at present planned, will vary from 17,500 k.v.a. to 220,000 k.v.a. The control of the water will involve the construction of four tunnels having an aggregate length of 73,825 ft. The completion of the development will represent a power-block of 450,000 k.v.a. The company has recently been compelled to authorise the immediate construction of power plant, Pit No. 3, the engineers to the corporation pointing out that the demands imposed are increasing at the rate of 7½ per cent. per annum, a contemporary increase of about 120,000,000 kw.-hours per year. This plant will be about 12 miles below Pit No. I, involves the construction of a diversion dam 125 ft. in height, and the driving of a tunnel some 22,700 ft. in length, to give 3,000 cub.-ft.-seconds flow. The power house equipment will aggregate about 100,000 h.p., and it is anticipated that this station will be ready by the autumn of 1925.

The most striking project yet advanced by the Californian power companies is that elaborated by the Southern California Edison Company. It is realised that the fulfilment of the various constructional programmes which have been prepared will result in the absorption of the whole of the hydraulic resources of the State by 1935. Accordingly the supply companies will be compelled to venture beyond the confines of the State for the production of further big blocks of power. Similarly, the rapid expansion in electric consumption compels the supply organisations to prepare their plans for extension many years in advance.

The new project of the Southern California Edison Company is identified with the Colorado River, and the Federal Power Commission has accepted the application for the preliminary permit to develop 3,000,000 h.p. This is the second largest river in the country draining 250,000 sq. miles and having an annual run-off exceeding 19,000,000,000 tons, the whole of which is discharged into the Gulf of California. According to the surveys it has been decided to establish the power-generating pivotal point 100 miles above the famous Grand Canyon. A dam, 500 ft. in height, is to be constructed between the towering cliffs, 800 miles above the estuary, and so will enable 93 per cent. of the annual precipitation to be conserved and turned to economic account. By the construction of the barrage a lake or storage reservoir, 200 miles in length, will be formed by the impounding of 48,616,000,000 tons of water. As the water level of this reservoir will be 3,000 ft. above the Pacific, adequate head of water will be available for the proposed chain of power houses.

While this reservoir will constitute the outstanding feature of development several subsidiary reservoirs are to be created at lower levels, not only to ensure the economic utilisation of the water several times over, but to catch the run-off from the smaller tributary watersheds. The Government is also sympathetic to the scheme because many far-reaching benefits, over and above the supply of electric energy, will be forthcoming, notably the regulation of the river. The Colorado is a turbulent waterway; the recurrence of floods in the lower reaches at seasonal periods causes widespread damage among the farms. Regulation of the flow throughout the year will overcome the inundation menace, because the flow will never be permitted to exceed what can safely be carried between the natural banks, rendering the construction and maintenance of costly dykes and levees unnecessary. Furthermore, control will facilitate the release of adequate water for irrigation during the dry season when the natural flow reaches its minimum, but when the agricultural demand for water reaches its maximum, thus preserving the crops. Irrigation will be performed by means of the electric motor-driven pumps which have become such a prominent feature throughout semi-arid and sterile California.

The ability to conduct irrigation along these lines will stimulate reclamation. According to the Government officials an additional 3,250,000 acres of land, at present semi-arid and neglected, will be rendered available for agriculture, 1,000,000 acres of which lie above the Grand Canyon, while the remaining acreage flanks the estuary. Finally, the creation of the huge reservoir and the subsidiary developments will bring 400 miles of what is now commercially useless waterway under navigation; the provision of such transport facilities will prove of incalculable value to the interior.

The generation of the huge output of electricity, aggregating at least 2,250,000 kw., from the Colorado River will supply sufficient power to satisfy the requirements of all the cities, towns and farms within a zone of 600 miles radius of the power station, the population of which at present is only 6,000,000, but this would undergo a rapid increase as the result of enhanced attraction forthcoming from adequate cheap power and reclaimable land. The Colorado River development will be commenced in the near future owing to the uncertainty of the power situation in the State of California, and the threatened early absorption of its hydro-electric resources.

Although the power supply companies are committed to the ten years' construction programmes and anticipate overtaking demand by 1930, they are perturbed by one thought. This is the possible decision of the railways threading California to adopt electric traction owing to the persistent rise in the cost of liquid fuel, and the threatened early exhaustion of the petroleum supplies. Should the railways come to such a decision within the next five years the electric power supply issue will become abnormally acute, and compel the generating companies to embark upon far more comprehensive schemes than they have yet contemplated.

LOW TEMPERATURE CARBONISATION IN VERTICAL RETORTS.

The plant first put in at H. M. Fuel Research Station for the low-temperature carbonisation of coal, an account of which was given last week in Engineering, page 168, had horizontal retorts working with disintegrated coal, which was charged on to trays divided into 3-in. cubes, the resulting briquettes of coke being removed at the end of the operation. The method thus had the disadvantage of being discontinuous, and attempts to provide mechanical means of charging, which might have led to a continuous process, were impeded by the fact that the working parts crept and got out of register when subjected to the carbonising temperature for any considerable time. Nevertheless the economy both of labour and of heat to be expected from a continuous process leaves the search for one among the objectives of the Fuel Research Board in their endeavours to realise an installation on the most economical lines; and in a report* just published an account is given of some results of low-temperature work obtained with the modified Glover-West vertical retorts that were put in at the station for the investigations on steaming in vertical retorts described in the last volume of Engineering (pages 734, 761 and 811), including trials of the effect of varying percentages of steam.

The report points out candidly that such experiments could not give a solution of the problem of the economical low temperature carbonisation of coal. As was seen in the previous report on low-temperature carbonisation, practical retorts resisting temperatures of about 600 deg. C. could be made in steel, and allowed a temperature to be reached in the interior within a few degrees of the furnace temperature. The vertical retorts, on the other hand, were built for work at about 1,300 deg. C., and so had to be constructed in some refractory material, such as silica brick, the much greater thickness and lower conductivity of which made it necessary to use temperatures in the combustion chambers 200 or 300 deg. higher than that which had to be reached within the retorts. The installation at the station, however, provides exceptional facilities for measuring the temperatures at different points of the plant, and the quantities and qualities of the various products; and it was felt accordingly that, in spite of the necessary difference between the conditions of low-temperature carbonisation in the station vertical retorts and those that might be expected in practice, the accurately measured data to be obtained by carbonising coal at a low temperature in these retorts would be desirable, both as giving general experience of results obtained in a continuous process, and as helping to define the design of retorts better adapted to low-temperature work.

The purpose of low-temperature carbonisation being primarily to obtain a coke suitable for domestic uses, which early experience had shown to mean one in which about 10 per cent. of volatiles remained, a series of tentative trials was made to determine at what throughput and temperatures such a coke would be obtained in the station vertical retorts. As was to be expected, the volatiles left in the coke decreased as the temperature rose, and also as the throughput was reduced and the time of exposure consequently increased. At a temperature as high as 1,000 deg. C. in the combustion chambers, finely disintegrated coal, such as had been used with horizontal retorts, seemed to form a hard crust, which passed slowly down the walls of the retort and allowed partially carbonised coal to pass more rapidly down the centre, while uncrushed coal gave good results. It was found desirable to drop the carbonising temperature,* and to increase the available heating length by burning gas in the top waste-gas circulating chambers. When carbonised without a considerable volume of steam the coke took fire on being discharged, and to reduce the amount of steam necessary to avoid this the position of the steam inlets was altered so as to cause the steam to pass through the coke in the coke chambers below the retorts before entering the retorts themselves. This reduced the amount of steam required for preventing ignition on discharge to not less than 4 per cent., and had also the incidental advantage of giving a gas of substantially higher calorific value; about 10 per cent. higher with 7 per cent. of steam. Trials were made of several coals and coal mixtures under various conditions.

As a result it was decided to carry out tests with no steam and with about 7 per cent., 13 per cent. and 20 per cent., under otherwise approximately identical conditions. The coal used was a mixture of 60 per cent. fusible and 40 per cent. non-coking coal, which had been found satisfactory in the horizontal retorts, but it was now used as uncrushed nuts, leaving about 20 per cent. on a 1 in. sieve and 90 per cent. on a ¼ in. The throughput, which, as will be remembered, is regulated mechanically in this type of retort, was 1·8 tons per 24 hours, and the carbonising temperature was to average about 780 deg. C., and to range from 700 deg. to 750 deg. in the four lowest combustion chambers to 850 deg. to 880 deg. in the waste gas chambers. As a fact, the intended mean temperature was attained within a few degrees in every test, though some variation was found in the temperatures of individual chambers. The passage of the coal through the retorts was found fairly uniform, though some poking was necessary. The retorts being 21 ft. high, the ascension pipes were found to be rather long for the low temperatures used, and gave rise to rather much condensation, which was got rid of satisfactorily by keeping the tar valve at the end of the collecting main constantly open. The separation of tar and liquor at the first or air-cooled condenser was quite satisfactory, but about 12 per cent. of the total yield was deposited at the water-cooled condenser, and was so light that the tar had to be run off at the top of the seal.

The test arrangements were as described in the previous report on "Steaming in Vertical Retorts" (see Engineering, *l.c.*). In the test with 7 per cent. steam the weight of charge (coal, steam and

* "Preliminary Experiments in the Low-Temperature Carbonisation of Coal in Vertical Retorts," H.M. Stationery Office; 9d. net.

* This expression is used throughout the report to denote the temperature in the combustion chambers, which was, of course, higher than that at which carbonisation took place within the retorts.

scrubber water) balanced the weight of products (coke, gas, dry tar and liquor) within 0·1 per cent. With no steam the balance showed a gain (3·3 per cent.), which is attributed to air having been sucked in, and with the higher percentages of steam losses of 2·1 per cent. and 2·9 per cent., attributed mainly to outward leakages of condensed steam. These differences, though higher than most of those obtained in the investigations at high temperatures, are sufficiently small for their purpose.

Separate proximate analyses were made of the coal used in each of the four tests, and showed it to be closely uniform. An assay made by the method devised for use with the horizontal retort trials showed, however, some notable discrepancies from the results obtained with the vertical retorts. The yields of coke on the laboratory and full-size scales were approximately the same, as had been found with the horizontal-retort investigations, and the yield of liquor in the retorts, which in the earlier investigations had been 1·29 of that of the laboratory assay, bore about the same relation to it in the present tests. The ratio for tar, on the other hand, which in the horizontal retort tests was only 0·62, was even less (0·53) in these; while for sulphate of ammonia it was now 3·2 as against 0·87 in the horizontal-retort tests, and for gas 2·2 as against 0·93.

While, therefore, the results given by the assay method seem not to be wholly irrelevant to those of carbonisation with the vertical retorts, they are obviously less closely related to these than to those of the process used with the horizontal retorts. This indeed is not surprising when the wide difference is remembered between the conditions of carbonisation in the two works processes, including apparently the duration of exposure and the variations of temperature in various parts of the retort. Besides the duration of exposure the freedom with which the gases are evacuated will also differ as between the two methods, and through both variations the extent to which products of combustion are broken down or combined before being discharged seem also liable to vary, such variations may lead naturally to grave differences both in the quantity of gas and other products evolved and in their respective compositions. If the low-temperature working of vertical retorts proves in fact to be successful it seems as though some alternative method of assay will be required, should the small-scale control of the working plant and selection of coals be considered as useful and desirable as it appears to have been in the working with horizontal retorts.

Some interesting observations were made on the variations of temperature within the retort. A ¾-in. iron tube closed and sharpened at one end was pushed down the centre of a working retort till the sharp end was almost at the bottom, and an asbestos-insulated thick iron-constantan thermocouple was passed down this tube and was read at intervals of 2 ft. from the bottom upwards. Several sets of readings were taken without steam and at each percentage, and the temperatures plotted against the heights from the bottom of the retort at which they were taken. These readings are said to have suffered from a tendency in the coal to hang up in the retorts for short periods, and then to travel down rapidly for a short distance, so that it was only by continued poking that "even reasonable results" were obtained. The differences disclosed by the thermocouple readings were remarkable, though somewhat irregular. With no steaming the temperature in the casting over the firebrick retort, about 22 ft. from the base, was about 70 deg. C., and rose very slowly for the first 12 ft. of the coal's fall, being only a little over 100 deg. C. at 10 ft. from the base. For the next 5 ft. it rose more rapidly, reaching about 300 deg. at 5 ft. from the base, and thereafter more rapidly still to a temperature of about 670 deg. at about 1 ft. 6 in. from the base, as against a temperature of little over 700 deg. in the surrounding combustion chamber. With steaming, the temperatures at the highest level still kept below 100 deg.; for some reason, with 13 per cent. steam it rose to about 200 deg. in the first 2 ft. fall, while with either 7 per cent. or 20 per cent. it did not reach that temperature till about 10 ft. down, or 12 ft. from the base. At about 1 ft. 6 in. from the base the 13 per cent. curve came within about 25 deg. of the temperature without steam, while at the same level the 7 per cent. and 20 per cent. temperatures were over 150 deg. less than the temperature with no steam. The 20 per cent. curve, moreover, at a level about 3 ft. 6 in. above the base of the retort reached a maximum of about 585 deg. C., falling to about 500 deg. in the next 2 ft., no similar regression appearing in any other part of this curve nor in any part of the others. These results seem to point to some unexplained source of disturbance in the temperatures; and having regard to the much higher temperatures of the combustion chambers and presumably of at least most parts of the walls of the retorts, to the low conductivity of the charge, and to the considerable differences in the thickness of charge that resulted from the retort's cross-section (33 in. by 10 in.), as well as to the possible effect of the temperature of the iron sheath in masking the true temperatures of the charge at levels above the lowest, some advantage might perhaps be found in taking temperatures by thermocouples supported at various levels in horizontal sheaths, and perhaps in obtaining readings at various points of the cross-sections.

The coke produced was in the form of large conglomerate masses fused firmly together, the original shape of the non-coking coal being distinguished clearly within swollen masses formed from the fusible coal. In size the coke varied up to 10 in. lumps with about 25 per cent. of breeze (below ⅞ in.), as against about 15 per cent. or less at the higher temperature of the previous trials; this difference may have been due to the grinding action of the extracting worm. On examination of the larger pieces of coke the coal appeared to have travelled down the retort with very little mixing action, some remaining always close to the wall of the retort and becoming more completely carbonised than that which followed the centre line. The effect of increased steaming was in each case to reduce the amount of breeze by a small amount; the percentage at 20 per cent. steam was 20·8, as against 24·8 without steam, the reduction being attributed to the alteration of the temperature distribution which appeared on steaming. The volatile matter left in the coke carbonised without steam was about 7 per cent., and fell to 6·8 per cent. and 6·3 per cent. with 7 per cent. and 20 per cent. steaming, while with 13 per cent. it rose to 7·2. Steaming at any percentage produced practically no difference either in the yield of coke (mean 14·3 cwt. per ton of coal) or of its combustibility.

The gas made varied regularly in quantity from 6,300 cub. ft. per ton of coal with no steam,* to 7,750 cub. ft. with 20 per cent. steam, in calorific value from about 700 B.Th.U.* to 640 B.Th.U., and in therms per ton of coal from about 44 to 49·6. The figures without steam compared with 3,050 cub. ft., 1,042 B.Th.U., and 31·78 therms obtained from the same mixture of coal carbonised at 600 deg. C. in the horizontal retorts. The tar also varied regularly from 12·72 gallons per ton of coal with no steam to 16·62 gallons with 20 per cent. of steam, as against 14·8 gallons with no steam in the horizontal retorts. The calorific values were all about the same, and the compositions similar. The yield of ammonium sulphate with no steam was 21·4 lb. per ton of coal, and with 20 per cent. steam 28·2 lb., as against 5·8 lb. from the same mixture without steam in the horizontal retorts. For some reason, however, only 20·6 lb. and 18·05 lb. were obtained with 7 per cent. and 13 per cent. of steam.

The heat spent on maintaining the setting at a temperature of 825 deg. C. was found by the method used in the earlier experiments on steaming to be 4·9 therms per hour, and the heat taken up by the coal for carbonisation and removal of the products at working temperatures was 6·3 therms with no steam, dropping to 5·3 therms with 7 per cent. steam and rising to 8·9 therms with 13 per cent. steam and 12·4 therms with 20 per cent. The drop with small percentages of steam is similar to that observed in the tests at the higher temperature, and is attributed to the condensation of the steam at the higher levels of the retort. The actual heat used compares favourably with what was required at the higher temperatures, which was from about 9 therms per ton per hour with no steam to 16 therms with 20 per cent. steam.

A rough test was made with a fairly fusible coal, which had been used successfully at low temperatures in the horizontal retorts. After crushing to a coarser size than the mixture used in the main tests this single coal was found at a throughput of 2½ tons per retort per day to give a considerably better and stronger coke than was obtained from the mixture, presumably owing to its uniform composition as compared with the heterogeneous conglomerate obtained from the mixture. It gave about the same output of coke and gas.

In the light of these results special retorts have been constructed in iron, and it seems likely, as the report suggests, that they may furnish or lead to a possible method of manufacturing good smokeless fuel. It would be convenient if methods could be devised for expressing the density and strength of the coke in comparable figures. When, moreover, other problems have been solved, some means of reducing the ash of coke, which at present constitutes about one-eighth of its weight, will probably have to be found if the coke is to be popular for domestic purposes, and possibly also for metallurgical uses.

* This was on a short-time test with the coke chamber doors, &c., luted to exclude air. In the main test without steam 7,190 cub. ft. were obtained with a calorific value of 640 B.Th.U., the discrepancy being attributed to leakage of air into the retorts.

NOTES.

ACTION OF BACTERIA ON CELLULOSE.

Though the action of bacteria on cellulose is hardly a problem for the engineer, the effects of such action have more than an academic interest for him. The engineer still asks the chemist in vain to tell him what coal really is; but it is at any rate generally admitted that coal is largely formed by the action of bacteria on vegetable matter in which the cellulose is broken down. When the chemist utilises this means in order to produce power alcohol and power gas from vegetable waste, or when cellulose (paper waste, &c.) has to be destroyed by bacteria in sewage, the engineer is again interested, as he has to design the technical apparatus in which such reactions are to be carried on. It was undesired bacterial action on cellulose, however, which was the subject recently of a discussion by the Society of Chemical Industry. In 1906, Sir Frederic Nathan, who opened the discussion, found that three cordite explosions which had occurred in India in that year were connected with a disintegration of gun-cotton. In 1917 supplies of cotton waste and cotton linters were found to have undergone similar disintegration in this country, and further investigation indicated that all celluloses are liable to attack by bacteria and moulds, acrobic as well as anaerobic, especially in warm and damp climates, and that their corrodibility varies with the kind of cotton and with its origin. The greater or lesser resistance of different cottons to bacteria attack is a matter of great importance, not only to the planter and the textile manufacturer. Though the differences may mainly be due to the amounts of non-cellulosic constituents present, it is generally believed that the cellulose in cotton fibres and the woody lignocellulose are more resistant than the pectocellulose of fruit and the hemicelluloses of pith, seaweed and of mangold-wurzels. In the retting of flax the action is to stop before the fibre is attacked; when straw and similar materials are to be converted into manure, or when maize waste, grasses and also straw are to yield alcohol by fermentation the action is to go further. At Nobel's factory in Ayrshire cotton waste is broken down completely to methane and carbon dioxide, the methane being wanted for experimental purposes. Power gas has been obtained from vegetable waste. The Continental attempts to convert sawdust and wood waste into alcohol and acetone by acid treatment and fermentation remain in the experimental stage. Probably success will some day be achieved, though at present the biochemical problems are still obscure in spite of the manifold researches carried out in this country by A. H. Lymn and H. Langwell, Dr. M. B. Hutchinson, Dr. F. C. Thaysen and others.

30-CWT. WAR OFFICE SUBSIDY LORRY.

We illustrated last week a 30-cwt. motor lorry built by Messrs. Clement Talbot, Limited, to comply

with the conditions which would entitle purchasers of lorries of the type in question to the Government subsidy of 40*l.* per annum. We have now received from the War Office a copy of the specification to which lorries coming under the subsidy scheme must conform. The requirements are explicit where necessary, but sufficient latitude is allowed to manufacturers to enable them to meet the stipulated conditions without unduly limiting their initiative in design. Makers, therefore, have quite sufficient freedom to encourage them to develop and perfect their own types, while the purchasers are assured that every vehicle conforms to a very high standard of material and design in respect of all essentials. The engine has to have a minimum R.A.C. rating of 24 h.p. and to be capable of developing at least 28 b.h.p. during a three hours continuous run, at a speed of revolution not exceeding that which would give a vehicle speed of 22 m.p.h. The petrol consumption must not be greater than 1 gallon per 18 net ton-miles, which is equivalent to 12 vehicle-miles per gallon. For the transmission gear neither leather-lined nor multiple-disc clutches will be accepted, nor may chain drives to the road wheels be used. Four speeds forward are to be provided, and the necessity for so many will hardly be questioned in view of the fact that the vehicle, fully loaded, must be capable of climbing a gradient of 1 in 4·5; must stop and re-start on a gradient of 1 in 5 in both forward and reverse gear; must climb an average gradient of 1 in 10 at 8 miles per hour for a quarter of a mile and must be capable of maintaining a speed of 30 m.p.h. for a mile and a speed of 22 m.p.h. for two hours on the level. In all cases a good hard road is assumed. The braking requirements are equally severe. Either brake must effectively stop and hold the vehicle when fully loaded on a gradient of 1 in 8 either forward or backward. Either brake must control the loaded vehicle, with the gear lever in neutral position, for half a mile when descending a gradient of 1 in 12 at a speed of approximately 8 m.p.h. without excessive heating. As a further test the vehicle will be brought to a standstill on a gradient of 1 in 5 and held by either brake; it must then restart and continue its journey up the hill, without the use of any scotch or sprag to assist starting. Starting must be effected in both forward and reverse gear under the above conditions. All brakes must be so designed that each can be adjusted within five minutes without the use of tools. The chassis may not exceed 33 cwt. in weight, nor may the body be more than 10 cwt. including driver's seat and canopy. The body must have a minimum internal length of 9 ft., a width of 6 ft. and a height of sides of 21 in. The useful load is to be 30 cwt.

Sperigyro Ship Stabiliser for British Admiralty.—The British Admiralty have recently taken delivery of a Sperigyro ship stabiliser of 78 in. diameter by 17·5 in. face, weighing 18,500 lb., which will be driven at a speed of 1,500 r.p.m. The apparatus was constructed by Messrs. Metropolitan Vickers Electrical Company, Limited, to the patented design and specification of the Sperry Gyroscope Company, Limited, London. The stabiliser is already installed and the result of the trial will be watched with considerable interest.

British Trade Marks in Japan.—The Commercial Counsellor to the British Embassy in Tokio wishes to draw the attention of United Kingdom firms trading or contemplating trading with Japan to the fact that cases frequently occur of the infringement by Japanese firms of United Kingdom trade marks. In this connection he wishes to impress on British firms the advisability of registering their trade marks in Japan, as by so doing they will not only protect their own interests but will enable the Japanese Patent Office to have a proper record for reference purposes and to cite the marks so registered against any subsequent applications for registration of similar marks in Japan.

Hamburg Quay Dues Increased.—The British Consul-General at Hamburg states that the Hamburg Trade, Shipping and Industry Board has announced that, as from July 18, the increase in quay dues at Hamburg has been raised from 289,900 per cent. to 666,900 per cent. The additional charges on storage rates are raised from 31,900 per cent. and 42,566 per cent. to 73,500 per cent. and 98,033⅓ per cent. respectively, while the minimum rate is fixed at 7,000 marks. A schedule showing the total new rates inclusive of the additional charges may be obtained by British companies upon application to the City Office of the Overseas Department (Shipping and Transport Section), 73, Basinghall-street, London, E.C. 2, where a copy of the original port tariff, in German, is available for consultation.

LITERATURE.

Industrial Hygiene and Medicine. By E. W. Hope, O.B.E., M.D., D.Sc., W. Hanna, M.A., M.D., D.P.H., and C. O. Stallybrass, M.D., D.P.H. London: Bailliére, Tindall and Cox. [Price 25*s.* net.]

This book attracts us in the preface which gives its purposes and aims, and frankly states that the movement for the betterment of industrial conditions has taken on an international character. It holds our attention throughout Chapter I, which serves as an introduction and a retrospect, and then leads us on to present and imminent problems, consideration being given to the details of almost every thinkable form of industrial work, in so far as they affect the health aspect and the co-related efficiency. The treatment of the subject is such as at once inspires the confidence of, and invites study by, the manufacturer himself. It is far more than a book for doctors.

The efforts after efficiency are traced from long ago, up to the present; from the time of Hippocrates and Galen, who even in their day drew attention to the injury and danger associated with trades such as lead-mining and pottery manufacture; through the waves of agitation and legislation in the earlier parts of the nineteenth century, right up to the situation to-day regarding which the authors state, "the standard of industrial hygiene and sanitation now reached will, as circumstances arise, be extended; there certainly need be no apprehension of any relaxation of efforts on the part of those who have the direction and supervision of this important work."

The present text-book lets us see precisely where we are, why we are there, and the all-round benefits of meeting the problems in a scientific and business-like fashion. There need be no alarm amongst employers regarding the contents of this volume. No private interests are invaded and the common weal, including the employer's, is helped by practical suggestions, tested by experience and fruitful in cash returns. No later than during the war, when so great a strain was thrown on factories in general and particularly on munition factories, close observation showed the direct connection between healthy conditions in the workshop and a large and steady output.

We come next to the chapter on Statistics, and here necessary warning is given regarding the many sources of error, and the great care required to avoid making unwarrantable deductions. The tables on page 36 show strikingly the deaths resulting from dust, lead, &c., in various occupations and at the same time make apparent the various immunities which are as an off-set to the hazards. We find that the United States Bureau of Labour Statistics have investigated the subject and typical figures from Hoffman's investigations are quoted. Here again the need for caution in making deductions is illustrated, because whereas a relatively low proportion of tuberculosis mortality is found when comparison is made with European experience, it has to be remembered that certain American insurance companies refuse to insure persons occupied in the worst of the dusty trades. Moreover, other features than dust have to be considered, and so on. It is likewise pointed out that the Report of the Ministry of National Service (1918) is not representative for the industries, or occupations reviewed, in so far as so many of the fit men of these industries were absent with the colours and so the lower grades of physical fitness tended to be unduly swelled.

The complicated subject is dealt with in a level manner and there is firm guidance for future statisticians.

Having thus seen how, and to some extent why, the worker becomes incapacitated, one starts the detailed review of his general hygienic conditions. Lighting, ventilation, heating, lavatory accommodation, baths, &c., are subjected to full review, from the practical standpoint. Helpful illustrations and designs are incorporated. The authors then proceed to disclose the application of the general principles to the specific branches of their subject—industrial poisonings by metals or gases; industrial bodily infections, like anthrax, hook-worm disease; occupational affections of the skin and the special senses, *e.g.*, the eye strain from insufficient illumination, and also from excessive light and heat, as in arc welding.

The scope of the work is comprehensive, and further leads from the general consideration of causative factors in industrial inefficiency, to the detailed review of what are classified as miscellaneous occupations—coal-mining, ore-mining, iron and steel and tin-plate manufacture, glass works, textile works, chemical works, marine service, and so on. Canteens and clothing and other subjects of welfare work are dealt with and likewise the physiology of fatigue, the employment of women and the prevention and treatment of accidents.

We find it recorded that from official inquiries, it is estimated that 35 per cent. of the accidents in coal mines could be obviated by taking a reasonable amount of care, that 9 per cent. are due to breaches of rules by the men and 1 per cent. to the breach of rules by officials. This fact alone demonstrates that much has yet to be done in the field of accident prevention.

As regards accident treatment, the requirements of the Home Office Orders for dressing and ambulance stations are scheduled and explained and practical advice is given. There is emphasised the necessity for adequate subsequent treatment, and, in this country, the particular need for the most modern methods for the reclamation of the disabled. The work of the special hospital at St. Helens, Lancashire, is quoted as an admirable example of the provision of facilities for immediate and secondary operations and other reparative measures.

A concise epitome of British legislation affecting industrial hygiene forms Appendix I, and Appendix II summarises the duties of local authorities under the Factory and Workshop Acts. A full index of authors and another of subjects assures ready reference. The type is clear, and the illustrations instructive.

The Internal Combustion Engine. Vol. I. *Slow Speed Engines.* By Harry R. Ricardo, B.A., A.M.Inst.C.E., M.I.A.E. London: Blackie & Son, Ltd. [Price 30*s.* net.]

This work on the internal-combustion engine, which, as admitted by the author, was prepared before the war, evidences the careful work, which is now expected from such an authority on the various phases on internal combustion. On the other hand, although the progress with the slow-speed type of internal-combustion engine with which this volume more particularly deals, cannot be said to have been anything like so rapid as with the high-speed type, due largely to the compelling force of war-time necessity in the case of the latter, yet when surveying the examples of standard practice given by the author it is quite evident that there has been a very steady development, even with the slow speed type. The thermodynamical theory underlying all types of internal-combustion engines has undergone little, if any, change for some considerable time, and it is only when thoroughly and completely expanded that these theories are worth reiteration in new text-books on this subject.

In the book under review, the theoretical side is not unduly stressed, and its various phases are very completely dealt with in the first eight of the 31 chapters. It is not an easy matter to form an exact balance as to where purely mechanical and constructional features influence theoretical considerations, but when dealing with the subject of mechanical efficiency, unquestionably these factors play an important part, and the design, the material, and the fit of the piston rings in an internal-combustion engine piston play a very important part.

Throughout the whole volume the influence of the author's work with the high-speed engine is suggested. In many cases the comparisons made between practice with small and high-speed engines are of considerable interest and utility, since undoubtedly lessons from one field of application can very often be applied with advantage to others, and working in watertight compartments will not secure the best rate of progress. Nevertheless, so different are the considerations between slow and high-speed engine work that there are, and must be, cases where comparisons are of little, if any, use. As an example of this point the question of reciprocating weights may be instanced. With high-speed

work reciprocating weights, primary because of the question of stresses in the bottom or big-end bolts, are of vital importance, whereas with slow-speed work, commercial considerations, long life, and wear, are the predominating factors, and an analysis of certain high-power slow-speed internal-combustion engines recently showed that the balance of advantages lay in retaining the weightier piston rather than adopting a lighter construction.

To some extent we must inevitably turn to high-speed work for data illuminating the various problems, since the amount of research work which has been carried out in the large slow-running engines is very limited, to some extent due to the cost and lack of facilities for making the necessary experiments. Nearly all mechanical engineering laboratories in our universities and technical schools have examples of the high-speed type of prime mover upon which to gather valuable data.

In dealing with constructional details, the volume under review cannot be said in any way to be exhaustive, and again the section which can be regarded as authoritative deals rather with the high-speed type. The subject of crankshafts, for instance, apart from balancing, is dismissed in a few words comprised in less than a page.

The latter half of the volume in the main describes the leading features and test results of types of engines, which were current when the data for this volume was being prepared, and it is considerable evidence of the progress which has been made in this branch of the subject, that the majority of the engines so described are now out of date, and description is therefore only of historical and not of current interest. As instances of this nature, and as evidence of the progress being made, we would mention the valve scavenging stepped piston-type of engine, the opposed piston two-cycle gas engine, the large two-cycle engines of the Koerting type, the duplex two-cycle multicrank gas engine, small two-cycle engines of the double piston, double and single crank types, and vapourising oil engines which latter have given place to those working either on the semi-Diesel or the high-compression oil cycles. In no branch of slow-speed work has more progress been made than with the Diesel oil engine, especially in the marine field, and again the engines described generally are not examples of present-day practice.

The work in this book has been very carefully done and forms a valuable addition to the literature on the internal-combustion engine, although an index would have been an advantage. This volume is to be followed by another dealing with the high-speed type, and its appearance will be looked forward to with keen anticipation by all students and those interested in internal-combustion work. In view of the enormous amount of research and investigation carried out by the author, its production will be awaited with keen interest.

The Manual of Up-to-date Organisation and the Science and Practice of Cost and Works Accountancy. By G. F. TURNER and B. WOOD. London: The School of Cost and Works Accountancy. [Price 10*s.* 6*d.* net.]

WE realise so fully the importance of good organisation and the need for accurate costs that we are prepared to welcome any book which is a real addition to the literature which already exists on the subject. We fear, however, we cannot so regard this latest book to our hand. The authors' desire is that the work shall be looked upon as a text-book and "a practical guide to all who have any pretensions to success in the world of industries." We cannot see that the authors have lived up to their title, their desire, or to their somewhat grandiose opening that "For the first time in the history of trade we shall review organisation as a science."

Read as a plain book on the subject we find the presentation is descriptive rather than "scientific," and in many cases the treatment is so superficial as to be of very little value. On the difficult but important question of the distribution of oncosts the references are particularly meagre. Four "principles" are recognised: Principle XXVI, the unit operator-hour assessment; principle XXVII, the percentage of overhead charges on the prime costs; principle XXVIII, the percentage of overhead charges on the labour costs; principle XXIX, the machine-hour costs—but the strongest lead given is at the head of page 138: "Therefore, the percentage basis of overhead charges, whether on the prime costs or labour costs, if these fluctuate, is not very safe, and, therefore, where practicable, the hourly basis is preferable because it is not subject to fluctuations." This opinion is arrived at because, in applying a general percentage to particular cases, the results given are not identical. It is obvious this will not be so excepting the example taken is a mean of the whole. There is no doubt whatsoever that the distribution of overhead charges on any other than a time basis will not give accurate results; there is little doubt either that the ineptitude which in the past has characterised the allocation of this very important item of cost has resulted in most misleading total figures being presented which have cost some firms dear, and the need for a truly scientific analysis is urgent.

Despite the recommendation made, however, examples are given later in the book, on pages 150 and 155, in which the overhead charges, in motor car manufacture, are assumed to be on a percentage basis and on the value of material as well as of labour. The overhead charges are said to be 150 per cent., and it is stated "if the prime cost of the car (without body), *i.e.*, the cost of material and labour is 300*l.*, the net cost of the car . . . would be 750*l.*" The reference is obviously to production rather than to commercial overhead charges, but in such a case it is quite out of keeping with general practice and logic to add overhead charges to material.

Treated as a text-book, the results are also disappointing. In a text-book we expect that references can be easily made and will be readily recognisable when found; that the examples given will be correct in substance and fact; that the right terms are used and that clarity of expression and meaning is an all-pervading feature. Our expectations are not realised.

Thus, if a definition of overhead charges be sought, the reader is referred in the index, under "overhead charges defined," to paragraph 134. This paragraph, however, commences "We may here give a specimen of the cost office log-book which contains evidence of facts which must be kept up to date." There is a reference later to overhead charges, but nothing which we would interpret as a definition. In the proceeding paragraph, however, it is noted that "Rule XIX defines the overhead charges." Reference to the index shows that under "Overhead charges rules" these are given as "Rules XIX and XXV, 130–132." Paragraph 130 covers 9 pages, but Rule XIX is to be found on the second (page 100), and reads as follows: "That the whole of expense charges plus the 'oncosts' be the overhead charges." Literally this may be held to be a definition, but for practical purposes it appears to have very little value.

We cannot think the authors really mean what they say on page 35, where the influence of scrapped units is being dealt with. The argument is, literally, that the greater the number of pieces there are scrapped, the more valuable the remainder become. "Now, if one of the units be scrapped after one pennyworth of labour has been expended on it and the rest are correct, the 99 units are worth 200*d.* Again, if 10 units be scrapped under like conditions the 90 correct ones would still be worth 200*d.*, and so on." This is not so; the cost per piece will be increased as pieces are scrapped, but the "worth" will not be affected. There are other instances of looseness of language, and, we think, of error in argument, but we forbear.

Apart from the inconvenience and uncertainty of some of the references the index is unreliable on other grounds. For example, "operation costing," "process manufactures," "object of operation costing," are indexed as being dealt with in paragraph 58, but that paragraph refers to tool checks, which item is also indexed as such under that head, and the same number. In the endeavours to present every source of information on certain points the book is made somewhat wearisome by the repetition of forms; one such appears no less than 17 times. As a result of this and other weaknesses mentioned those features, which may be good, are likely to be overlooked.

We fear the authors have not realised that writing is a responsibility as well as a privilege not only to the reader but to the subject itself. In costing there has been so much done badly, and we have reasons to think, is still being so badly done or left undone, that any writing which is not clearly a help tends to fog the man who is looking for guidance and to prejudice his outlook accordingly. In this book there is a "preface to lectures"; we would suggest that good lectures do not necessarily provide a suitable basis for a text-book, and where such important subjects as costing and organisation are concerned, a wide practical and technical experience and careful writing are essential if readers are to be given the assistance they have a right to expect.

Timothy Hackworth and the Locomotive. By ROBERT YOUNG, M.I.M.E. London: The Locomotive Publishing Company, Limited. [Price 21*s.* net.]

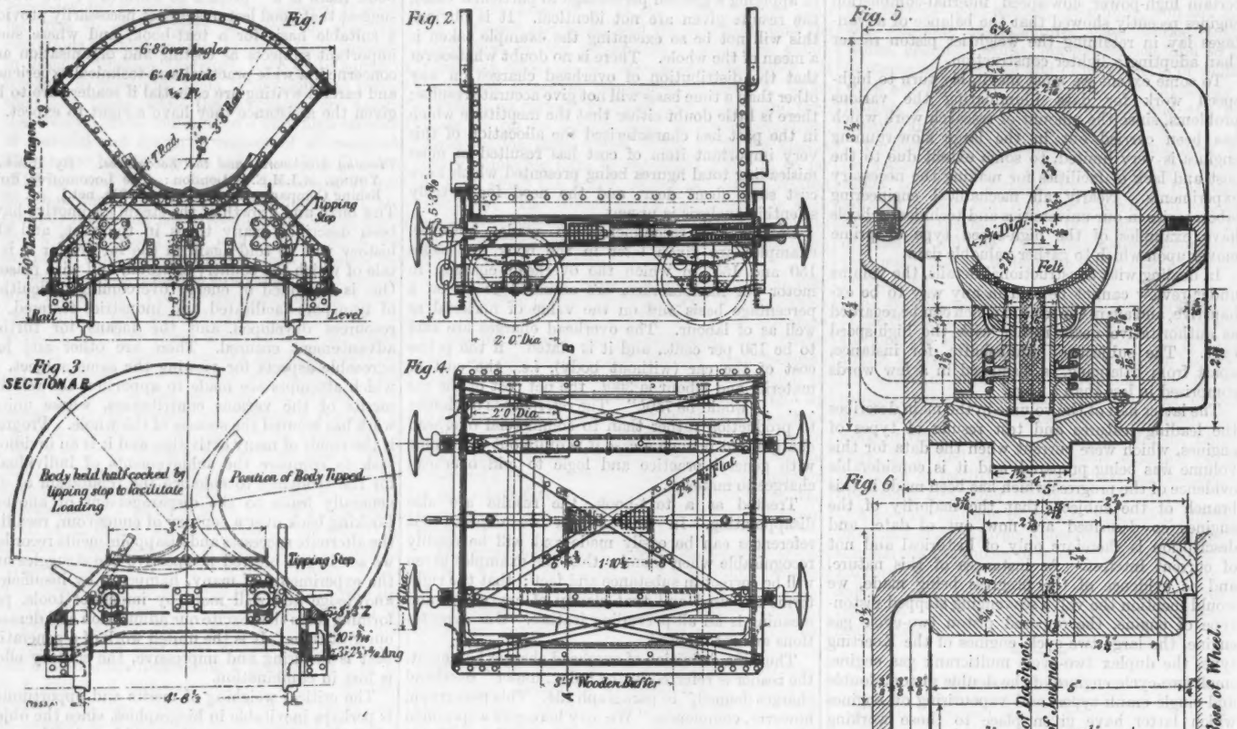
THE birth and growth of the steam locomotive have been described many times in the past, and the history will be told again in the future, for it is a tale of which the country is proud, and with reason. One is reminded of energy overcoming difficulties, of transport facilitated and industries fostered, of resources developed and the means for further advancement ensured. There are other and less agreeable aspects for viewing the same subject, in which attempts are made to apportion the relative merits of the various contributors, whose united work has secured the success of the whole. Progress is the result of many activities, and it is an invidious task to compare the achievements of individuals, for the tendency to enhance the reputation of one generally leads to the disparagement of another. Looking back over a century of endeavour, recalling the alternate successes and disappointments recorded, we see in the blurred perspective the struggles and the experiments of many, hampered by insufficient knowledge and still more by imperfect tools, performing feats that excite our admiration and demand our gratitude. It is the united work of a generation that is inspiring and impressive, the solitary effort is lost in combination.

The critical weighing of merits and opportunities is perhaps inevitable in biographies, since the object of authors is to place their subject in the most favourable light and to claim full recognition for whatever worth he has displayed. Mr. Young cannot escape entirely from the objectionable practice of comparison, but though he evidently ranks the firm of Stephenson, as engine builders, inferior both in ingenuity and workmanship to that of Hackworth, he is neither offensive in his treatment of one nor fulsome in the championship of the other. He intends to be fair in his judgment, and impartial in his statements, but evidently great differences in the characters and the aims of the two men, who so materially forwarded the interests of the pioneer railways on the East and West Coasts, respectively, easily make any comparisons misleading. The modern spirit of commercialism developed in the Stephensons, while Hackworth was animated by the desire to promote scientific ends. Robert Stephenson was alive to the economies of mass production, and was content to reproduce an approved model. Hackworth, bent on mechanical improvement, would rarely produce two engines to the same pattern. The rewards bestowed on Stephenson and the place he occupies in history were never coveted by Hackworth, who, labouring not less diligently and not less successfully, was content to enjoy the approbation of his employers and, later, the respect of his clients. In the days of clamorous self-advertisement there is certainly great danger that the work of the modest and unassuming will be overlooked, and it is with the object of presenting the achievements of Timothy Hackworth in connection with steam locomotives in their proper perspective, that the author has undertaken this history.

The figure presented is that of one who was capable and eager in his work, upright and honourable in conduct, maintaining a high standard of workmanship and using this knowledge and influence wisely among his workpeople. In days when the needs for improvements in the condition of the working classes were not so much neglected as they were unimagined, he sought to advance the social welfare of those with whom he was brought into contact, and Hackworth's name would deserve to be remembered though his skill and ingenuity had added nothing to the advance of engineering

TIPPING TRUCK FOR GAS WORKS.

CONSTRUCTED BY THE SOUTH METROPOLITAN GAS COMPANY, LIMITED.



science. The list of inventions with which his name is connected is, however, long and noteworthy, far too long to be quoted in full, but it forms the subject of an appendix to which reference should be made by those, who would learn what was accomplished in a single lifetime, and by those who would contrast the state of locomotive construction at the time when Hackworth was experimenting on the traction force of plain wheels on smooth rails, and urging reconsideration of the views held by George Stephenson and Trevithick, to these later dates within the memory of some now living, when the *Sanspareil* No. 2 was placed on the rails, with many of the features that distinguish modern work.

When the results accomplished are compared with the mechanism provided, an increased respect should be entertained for the men and leaders who triumphed over all difficulties and made steam locomotion possible. Few were held in as high a repute by their contemporaries as was Hackworth, and his name is deserving of greater recognition than it has hitherto received. He worked in days when engine drivers were unsheltered from wind and weather, and were often required to encourage an unwilling engine by a crowbar. No brake was supplied to either engine or tender, and the only way of controlling trains was to put the engine out of gear, or for the firemen to get off and put down as many wagon brakes as they thought necessary. There were no grease boxes and after running a mile, the journals had to be oiled by hand, an operation that had to be repeated every dozen miles. These and many other inconveniences have been gradually removed, but no one has worked more strenuously or with better effect than the subject of this memoir.

BOOKS RECEIVED.

How to Organise and Conduct an Export and Import Business. By R. Osborne. London: Effingham Wilson. [Price 4s. net.]

Automatic Telephone Systems. Vol. II. *Auxiliary Services and Private and Branch Exchanges.* By William Aitken, M.I.E.E. London: Ernest Benn, Limited. [Price 35s. net.]

The Ventilation of Public Buildings. By Robert Boyle. London: Robert Boyle and Son. [Price 6s. net.]

Domestic Sanitation and House Drainage. By Henry C. Adams, M.Inst.C.E., M.I.Mech.E. London: Henry Frowde and Hodder and Stoughton. [Price 10s. 6d. net.]

A Dictionary of Applied Physics. Vol. V. *Aeronautics—Metallurgy. General Index.* Edited by Sir Richard Glazebrook, K.C.B., D.Sc., F.R.S. London: Macmillan and Co., Limited. [Price 63s. net.]

Die Gasmaschinen, Explosions und Verbrennungskraftmaschinen. Part I. *Die Generator zur Gaserzeugung.* By Albrecht von Ihering. Leipzig: Wilhelm Engelmann. [Price 29 Swiss francs.]

TIPPING TRUCK FOR GAS WORKS.

An interesting type of tipping wagon, with special provision to resist heavy shocks on the bearings, is shown in Figs. 1 to 6 above. It was designed by Messrs. Charles Carpenter and T. S. F. Gibson for use at the East Greenwich Station of the South Metropolitan Gas Company and was constructed at their works under the superintendence of Mr. T. Curr, the resident engineer.

The skip or body is mounted in the usual manner on curved bulb angles which roll upon suitable flat paths to allow it to be set in positions which are suitable for loading or discharging. Tipping stops are used to hold the body in place and to keep it in a half-cocked position for loading or allow it to be completely tilted for emptying. Deep end frames with angle section stiffeners support the paths and are riveted to the Z sections, angles and plates which serve as side frames. These side frames act as shields for the protection of the wheels and axle boxes from the dumped material and as supports for the springs. Bracings in the form of flat bars, arranged diagonally, prevent the frame from being racked out of its rectangular form, and additional longitudinal stiffening is provided by tubular struts which transmit the thrusts on the buffers and give a suitable housing for the coiled buffer springs. The construction of these and of the drawbars is shown in the sectional view, Fig. 2 and plan, Fig. 4.

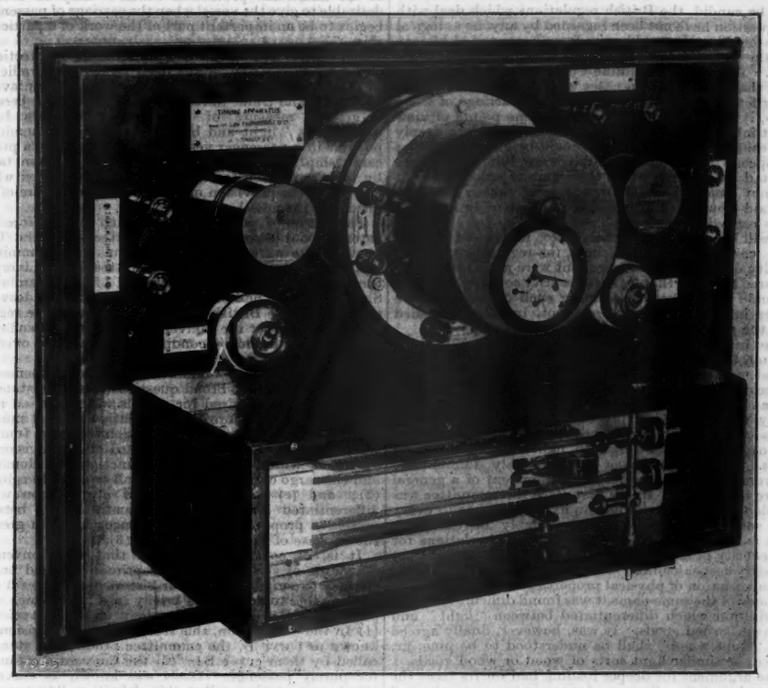
The axle-box is perhaps the most interesting feature of the design and is shown in detail in the two drawings, Figs. 5 and 6. When any tipping truck is discharged at one side a lifting action on the other side is experienced. When this happens the top brasses leave the journals and return with some amount of shock when the distribution of the weight on the four wheels again becomes normal. The arrangement used in the truck illustrated, was introduced to get over this shock and the consequent wear and tear of the bearings which it entails. This is effected by maintaining the contact between the journals and the bottom brasses under all conditions. The lower brasses are mounted on hollow plungers carried on springs of just sufficient strength to overcome the effects of gravity and friction. As the plungers work in oil cylinders from which the entry and egress of the oil is restricted to passage through a single hole of $\frac{1}{32}$ in. diameter in each, any suddenly applied stress is resisted by the dash-pot action. Not only is the effect of the jarring action of tipping prevented in this way, but also those of rolling over irregularities in the track. The lower brasses receive their lubrication from wicks dipping into the oil reservoirs below the bearings in the usual manner, and the brasses are provided with suitable recesses for the accommodation of the ends of the wicks and the passage of the oil.

The track throughout the works for which these trucks were designed is of standard gauge, but some parts of it are not adapted for ordinary rolling stock because of the smallness of the radius of some of the curves. The type of truck illustrated is intended for use in those parts of the system. The buffer and coupling dimensions were determined on the consideration that for shunting purposes trains may be made up of ordinary rolling stock as well as of these trucks.

Squirrel-Cage Induction Motors with High-Starting Torque and Reduced Starting Current: Errata.—Owing to a printer's error the third and fourth items in the list of definitions in the third column on page 164 of our issue of last week appeared as "ohms" instead of "mhos." The errors are in lines 39 and 41. The same mistake was repeated in line 10 of the centre column on page 165.

PORTABLE CHRONOSCOPE TIMING APPARATUS.

THE LOW ENGINEERING COMPANY, LIMITED, LONDON.



The accompanying illustration is reproduced from a photograph of an instrument made by Messrs. H. Tinsley and Co., for the Low Engineering Company, Limited, 92A, High-street, Kensington, London, W. 8, and used to give a highly accurate indication of the time interval between the operation of two electrical contacts. The particular instrument illustrated has been supplied to the Auto Cycle Union for timing motor-cycle races by means of contacts fitted into the surface of the track and operated by the vehicle passing over them, but it can be employed equally well for timing the movements of other bodies and for a great variety of experimental work involving the accurate measurement of time intervals.

The apparatus comprises a phonic motor, the speed of which is controlled by an electrically-operated tuning fork clearly visible in the illustration. The phonic motor drives the chronoscope mechanism so that the central hand makes a complete revolution of the dial in one-tenth of a second, and as the dial has 10 main divisions, each of which is sub-divided into 10 equal parts, it is possible to obtain readings to 0·001 second and to estimate to an even higher degree of accuracy. Three small integrating dials on the chronoscope give readings in tenths of seconds, seconds, and 10 seconds, so that a total time of 100 seconds elapses before the reading of the instrument is repeated. With the aid of an ordinary timepiece it would, however, be possible to measure time intervals of any length, since the chronoscope can be allowed to run continuously.

Current for the phonic motor and tuning fork is supplied from a 12-volt accumulator and, in operation, the motor is started by hand and allowed to run until required without driving the chronoscope. The latter is started by a trip relay electrically connected with one of the track contacts, and stopped by a second relay connected with the other track contact, so that the chronoscope reading gives the time interval between the passage of a vehicle over the two track contacts in succession. The two trip relays are enclosed in the small brass cylindrical cases seen on each side of the chronoscope in the illustration, and below each of them is a tumbler switch. By means of these switches the relays can be disconnected from the track contacts, except during the passage of the particular vehicle it is desired to time.

The apparatus is quite portable, weighing less than 20 lb., without the accumulator, and it is generally used with the base board horizontal; the vertical position shown in our illustration was adopted merely for convenience in photographing. We should mention, in conclusion, that the relays can also be operated by the breaking of a thread, and in other ways, if desired. It is only necessary for the circuits to be made momentarily in order to trip the relays and so start or stop the chronoscope mechanism. Whether the track contact remains open or closed after operation is immaterial, since once the relays have been tripped they cannot operate again until they have been re-set by hand.

INTERNATIONAL REGULATIONS FOR LOAD-LINES, DECK CARGOES AND SAFETY OF LIFE.*

By Sir Westcott S. Abell.

At a gathering of this nature, a more useful purpose may perhaps be served by discussing the trend of modern opinion in regard to the ship—the instrument of transportation—and the risks she has to face, than by dealing with any particular technical problem. True, there are many technical puzzles awaiting elucidation, but a technical problem is, after all, only of interest to a comparatively small section of the community, whereas the ship and the risks she encounters are subjects vital to the whole of civilisation.

The ship was one of the first of man's works, and from the earliest history the risks attendant upon sea travel have occupied man's attention; not only has this been so, but when forms of settled government began to emerge, the importance of rules to govern sea trade was at once recognised. At the beginning of the Christian Era, if not before, the trading community of the island of Rhodes set up a Code of Sea Laws, known as the "Rhodian Sea Law." The Romans, great law makers though they were, accepted these laws without modification when they conquered the island, and they were afterwards incorporated in the Justinian Code—the basis of our modern legal system. There is abundant evidence, too, that the great trading Republics of Venice, Genoa and Sardinia (circa 1,000 A.D.) laid down and enforced a series of most detailed laws for the loading and construction of ships and for the carrying out of trade. The laws of Sardinia, in particular, required the painting on a ship's sides of a loadline mark—a white circle—almost identical with the mark in general use to-day. Later still, the Hanseatic League set up similar sets of decrees for the conduct of its sea traders, which were enforced until the opening of the ocean routes of the world, as distinct from the old headland-to-headland coasting tracks, robbed the League of its power.

With the discovery of America and the consequent rapid expansion of trade, nations rather than communities of traders began to adventure overseas, and so, in their turn, nations began to set up systems of sea laws and to incorporate them in the civil law of their country.

The opening up of the trade routes, and the ensuing race for world trade supremacy, led to national animosities which culminated in a series of conflicts in which country after country claimed the "freedom of the seas." It was left to experience, bitterly bought, to teach the world that freedom of the seas is an international necessity and that the freedom of the seas involves freedom both of ship and of access to trading ports. Nor was this all: the stern teachings of experience made evident the fact that, despite the machinations of national diplomacy, any national flag, however powerful politically, could not render any aid to the ship when the testing storm sought to prove it—in that day, careful design, honest workmanship and skilled operation could be the only safeguards.

Thus came about the gradual realisation by the shipping industry of the need for international understanding, and the belief that it should be possible for those engaged in shipping to frame a standard of conduct which would be fair to all communities taking part in the international industry of sea trade. For a long time the political machinery of the various countries interested in maritime affairs was used to further this ideal. A good deal of work was done by the International Law Association and the Comite Maritime International, mainly in connection with legal, financial and trading liabilities, and even, incidentally, in reference to the question of loadlines as affected by deck cargoes. The greatest measure of agreement reached prior to the war (that in regard to tonnage regulations), was, however, the result of action by the various governments. With the exception of the Suez and Panama Canal regulations, tonnage measurement throughout all maritime countries came to follow very closely the British practice.

Government action, too, was responsible for the degree of uniformity obtained in regard to freeboard matters, and in this respect the conflict between the German and British national laws will not be forgotten. Considerable political pressure was necessary before it was found possible to obtain an agreement between the two countries on this question; but the difficulties were overcome, and the freeboard tables made approximately equivalent.

It was apparent, however, that an internationally-recognised code of regulations applicable to overseas trade was necessary; and the great convention called in London after the Titanic disaster led to the idea that it would be desirable to hold an International Conference on the question of loadline. The committee appointed for that purpose reported to the British Board of Trade in December, 1915. The war, however, put a stop to the furtherance of these discussions, and the time of the various Governments has since been so occupied with what may be termed "political" conferences that it appeared there would be no chance for attention to be given to the preparation of international ship regulations.

It was in these circumstances that the Chamber of Shipping of the United Kingdom and the Liverpool Steamship Owners' Association came to the conclusion that the time was ripe for the shipping community itself to take some direct part in the matter, and, at their invitation, an International Conference of Shipowners was held in London in November, 1921. This conference, which is of historic importance, had for its motive the examination and discussion of the various phases of sea activity. Several committees were appointed, some to deal with legal matters, some to deal with trade conditions, and others to deal with the ship herself. It is of these latter committees (with which the writer was more intimately connected) that some account will be given, in order that the great progress which has been made in these matters may be fully appreciated, and in order that the manner in which some of the results were obtained may be explained in a broad way.

Loadlines for Cargo Vessels.—It seems desirable to recapitulate briefly the modern history of the subject. In the early part of last century, Lloyd's—and, later, other underwriting associations in England—made empirical rules for the assignment of freeboard, but it was not until 1870 that there was any great public agitation in Great Britain with regard to unseaworthy ships. In that year Samuel Plimsoll, whose name will be for ever associated with this question, raised a storm of popular protest by his extravagant allegations. Lloyd's Register was early associated with the subject. In 1875 the society endeavoured to formulate a system of freeboards, and in 1882 definite tables were issued, practically concurrent with rules produced by the British Board of Trade.

The first British Load Line Committee issued a report in 1885, containing tables for maximum loading, which were largely based on the proposals of Lloyd's Register. The Merchant Shipping Load Line Act of 1890 made the marking of loadlines compulsory, and a subsequent Act of 1906 required all vessels using United Kingdom ports to be subject to the same regulations as British vessels. The 1885 rules were adjusted in 1906, and from that time onwards British, French and German regulations were practically in agreement. While at the present time many nations are in accord with these regulations, yet Norway still allows a somewhat smaller freeboard for small vessels, and in spite of many efforts the United States has not yet passed an Act making compulsory the marking of a loadline.

A Special Committee appointed by the Board of Trade to formulate freeboard regulations suitable for international application reported in 1915, and it is the report of this committee, consideration of which was suspended during the war, which was the basis for the work of the Committee of the International Shipping Conference appointed to deal with this question.

The freeboard regulations as originally formulated seem to have embodied the following premises: (*a*) The provision of a certain reserve of buoyancy which increased up to a higher limit as the size of ship increased; (*b*) the maintenance of a sufficient "height of platform" at the bow and at the navigation position; and (*c*) the provision of a certain structural strength.

The Board of Trade Committee reviewed the whole of

* Paper read at the Swedish Naval Architects meeting at Gothenburg, August 14, 1923.

the experience obtained since detailed freeboard regulations had been in operation. They found that favoured treatment had to some extent been accorded to certain types, *e.g.*, the shelter deck and well-deck vessels, to the disadvantage of equally seaworthy classes, such as the "three-island" ship. These concessions in the case of shelter-deck vessels seemed to have arisen mainly by giving allowances for the buoyancy of spaces which were exempt from tonnage measurement, and the committee proposed regulations which reduced the buoyancy allowance for spaces which by law were regarded as open to wind and weather. They also proposed adjustments to the allowances for superstructures which gave a better height of platform at the desired places, and which varied with the degree of protection which the superstructures gave to the vessel considered as a whole.

In order to provide for the third point in freeboard assignment—"a standard of structural strength in relation to draught"—an exhaustive examination was made of the requirements of the various classification societies, viz., Lloyd's Register of Shipping, the Bureau Veritas, the British Corporation, and the Germanischer Lloyd, who co-operated in this work. As a result, formulæ were prepared for the determination of longitudinal and transverse strength in relation to dimensions and draught, as well as for the thickness of side plating in association with the spacing of frames. By this means it was possible to apply four tests which would indicate whether the general arrangement of the structure was sufficient for the geometrical draught. The Board of Trade Committee considered that it was most important to ensure that all openings in the decks and sides of vessels should have proper means of closing, in order to maintain the buoyancy of the vessel, as the ordinary freeboard regulations were not concerned with the internal sub-division by bulkheads.

The committee examined the existing freeboard tables in the light of past experience, and of their proposed modified allowances for superstructure. They produced a set of tables which gave directly the freeboards for flush-deck vessels of standard proportions, and the allowance for such vessels when the uppermost deck was the top of a complete superstructure. The figures contained in these tables were arranged so that in standard vessels the actual freeboards were in agreement with previous practice; this, of course, meant some increases in special types which previously had been given more favoured treatment.

The International Shipowners' Committee in dealing with these various points came to the conclusions that:—

(*a*) The freeboards for flush-deck vessels were generally acceptable, but might perhaps be still more increased.

(*b*) The freeboards for shelter-deck vessels with tonnage openings should be maintained at the same figures as formerly. The disparity between "tonnage" and "freeboard" requirements was not due to unsatisfactory freeboard assignment, and it was the "tonnage" regulations which required modification.

(*c*) The standard height of superstructures forward of amidships should be increased.

(*d*) While the proposed standard of strength might generally be acceptable (it was pointed out that the new Japanese regulations had adopted the standard practically in its entirety), yet some opinion was expressed that the recognised authorities might be allowed to set up their own standards.

(*e*) The reductions of freeboards permitted for summer seasons in relatively small areas, such as in the Indian Ocean, might be extended to other parts of the world which experienced similar climatic conditions.

(*f*) The freeboards for sailing ships should be determined by the steamer rules, such an addition being made as would maintain existing practice for such ships.

(*g*) Some attempt should be made to devise a physical determination of a steamer in such a way as to permit of a grading between the sailing ship and steamer freeboards. It was suggested this definition should be based upon a relation between horse-power and displacement.

The International Committee considered that the first step to be taken towards official acceptance was to forward the report in its entirety to the British Board of Trade, and to suggest that the views expressed therein might be taken into consideration in any proposed modification of the freeboard regulations. The statutory Committee which advises the Board of Trade on these matters has been asked to give consideration to the report, and their conclusions may be expected before very long. While it is not possible to forecast these conclusions, it can safely be said that the report of the Shipowners' Committee has been of invaluable help to the British Government, and that every consideration has been given to the results of the experience which the report contains.

The Carriage of Deck Cargoes.—This subject is of particular interest to Scandinavians, who have made a very special study of it, and whose experience, particularly in regard to the carriage of light wood goods, has been unique, and, what is more, satisfactory.

It may be of interest to point out from the particulars available of the distribution of Swedish wood goods, that in 1922, 37½ per cent. of the exports were taken by the United Kingdom, and another equal amount by France, Holland and Belgium together; of the remainder, Denmark, Norway and Germany took 12½ per cent., and other countries the balance of 12½ per cent. These figures were very much the same in pre-war days, except that Germany took a very much bigger share before the war. It might also be pointed out that Great Britain takes 50 per cent. of the Swedish wood goods which are carried in vessels trading outside the Baltic.

As an illustration of the experience which has been obtained by Norwegian vessels in the carriage of light wood goods, it may be interesting to mention that the total losses which happened in that trade from 1906 to 1919 either from the vessels being missing, having been sunk, or having been abandoned, were remarkably small. There were no losses whatever in nine of the years mentioned (1906, 1908, 1910, 1911, 1912, 1913, 1914, 1918, 1919), only one loss per annum in the years 1909 and 1916, and two losses per annum in 1907, 1915 and 1917.

To be candid, the British regulations which deal with this question have not been regarded by anyone as logical or reasonable. It would seem from a perusal of history that the question has rather been avoided than encountered. The British Loadline Committee of 1915 recognised that: "In certain cases where ships are specially constructed, or specially fitted, for the carriage of wood goods, it might be contended from some points of view that timber-laden vessels could be loaded more deeply than other vessels, provided it could be guaranteed that the special conditions required were fulfilled." They reported that on the whole they were of opinion that it was not desirable to allow a special timber loadline, but laid down certain rules for the security of wood goods carried on deck.

It will be seen that this committee recognised (*a*) that there was an international need for regulations for the security of wood deck cargoes, but were not at that time prepared to admit that (*b*) such security could be obtained as would enable vessels carrying such cargoes to have deeper immersion. They were not, in short, satisfied with the regulations for security of such cargoes.

The International Deck Cargoes Committee held its first meeting in Christiania in February, 1922, and its second meeting in London in April, 1923. The existing Norwegian rules were taken as the basis for discussion, and at the second meeting rules and regulations were finally completed for: (*a*) The carriage of light wood goods; (*b*) the carriage of heavy wood goods; (*c*) the freeboard allowances for both light and heavy wood goods. These regulations are probably familiar to everyone here, and therefore only comment of a general nature is required. In the first place the committee was satisfied that the Scandinavian experience was in every way satisfactory and could reasonably be extended. That is, they were of opinion that the regulations for the security of deck cargoes of light wood were sufficient to justify deeper loading, within limits. Naturally, owing to the variation of physical properties of different classes of woods of the same name it was found difficult to devise a definition which differentiated between "light" and "heavy" wood goods. It was, however, finally agreed that "light wood" shall be understood to be pine, fir, spruce, or similar light sorts of wood or wood goods.

The argument for deeper loading had for its basis the proposal that the allowance for superstructures of wood goods should be half that permitted for a similar fully-enclosed steel superstructure, consequently it was necessary to require that for heavy wood goods the deck cargo must consist of squared timber, or lumber, of such dimensions as can reasonably be stowed into a solid deck load.

Dealing with the freeboard allowance, the committee considered that: (1) The allowance for "light" wood goods should be one-half that for a corresponding steel structure; (2) the allowance for "heavy" wood goods should be 70 per cent. of that given for "light" wood goods; (3) any reduction of freeboard should not exceed 9 in.; (4) all vessels must have a forecastle and a superstructure protecting the deck openings to the machinery; (5) hatchways, ventilators and other deck openings are to be properly protected; (6) the strength of the vessel must conform to the requirements for the highest class of a recognised classification society. As to the security of deck cargoes, it is to be observed that the only limitations of height laid down were: (*a*) The deck cargo must never be so high as to obstruct the outlook from the bridge, and (*b*) the height of "heavy" wood goods must not exceed 8 ft. above the freeboard deck in "winter." The general conclusions of the committee were that: (*a*) The deck cargo should be supported by stanchions housed in deck sockets spaced not more than 3 m. apart; (*b*) eyebolts should be attached to the main structure spaced not more than 3 m. apart; (*c*) all stanchions and eyebolts must be of adequate strength in relation to the height of deck cargo; (*d*) there must be one efficient lashing for the deck cargoes up to the height of the superstructures, and (*e*) for greater heights of deck cargoes, there must be either separate lashings for that part above the height of superstructures in the case of "light" wood goods, or additional eyebolts and lashings in the case of "heavy" wood goods.

It was important to maintain in some way the necessary stability of the vessel during the voyage, and it was considered that the vessel should be upright, *i.e.*, without a list, on leaving a loading port, and that the arrangement of water ballast and stowage of cargo should be such as to provide a sufficient margin for adjusting the stability, or rather the condition of zero list during the voyage. In addition, attention was drawn to the necessity of supporting the deck from below in order to carry the deck load. Various regulations were also formulated to protect the crew, the navigation and the life-saving appliances.

The procedure followed by the Chamber of Shipping in submitting these regulations to the Board of Trade was the same as for the loadline for cargo vessels, but the difficulties of the British Government in dealing with this phase of sea regulations are by no means light; for, contrary to the usual custom, it happens that the detailed regulations in this case are contained in the Merchant Shipping Acts themselves, and to modify an Act of Parliament is not so simple a procedure as to modify regulations which give effect to a principle contained in an Act. However, the British Board of Trade are fully alive, firstly, to the importance of the question, and secondly, to the difficulties of procedure, and will no doubt afford every opportunity for fair consideration to be given to the case. It is, moreover, distinctly encouraging to note that the International Labour Bureau of the League of Nations have resolved to support the proposed legislation without qualification.

Loadlines for Passenger Vessels.—The third phase of the loadline question resolves itself into a consideration of the additional protection which it may be deemed desirable to give the vessel when the carriage of passengers begins to be an important part of the work of a particular ship.

The mere statement of "additional protection," without qualification, seems itself to be a contradiction in terms, not because travel at sea compares unfavourably with land traffic in respect of accidents, but because a greater measure of protection—passengers being regarded as "light and bulky" cargo—is economically possible in a passenger vessel as compared with a purely cargo ship. This was the view of the problem taken by the Convention for the Safety of Life at Sea which associated the provision of safety with the nature of the service of the vessel.

The basis of consideration, which was before the International Sub-division Committee, was the Convention, the work of the British Bulkhead Committee, and the reports of the Joint Committee of the Liverpool Steamship Owners' Association and of the Chamber of Shipping, which had been at work since 1916, endeavouring to show the British Board of Trade that the regulations issued under the Convention did not pay sufficient regard to the economic conditions of passenger overseas traffic.

The International Committee concerned themselves primarily with three broad questions: (*a*) The standard of sub-division required for vessels which carried more than 12, but not more than a relatively small number of passengers, *i.e.*, for vessels in which the cargo function was dominant (1); (*b*) the standard of sub-division for vessels in which the passenger function was dominant and the cargo carried was very small or almost negligible (2); and (*c*) the preparation of a definition which differentiated gradually and continuously between vessels in proportion as the passenger function grew at the expense of the cargo function (3).

It is, of course, well known that the Convention standards of sub-division were primarily based on the German experience, which for historical purposes it may be desirable to summarise briefly in a form which compares with the actual phraseology of the Convention: (1) In the Convention, this standard of sub-division was known as curve B, the committee produced a standard called by them curve B1; (2) the Convention standard for purely passenger vessels was known as curve C; (3) the convention called this definition "Criterion of Service," which was left for further study by the Bulkhead Committee and by other nations.

Length of Vessel.	Factors of Sub-division. German. Cargo-Passenger.	German. Fast Passenger.	Convention. Curve B.	Convention. Curve C.
ft.				
Up to 330	1·00	1·00	1·00 to 0·97	1·00 to 0·76
330 to 390	0·88	0·85	0·97 to 0·86	0·76 to 0·62
390 to 490	0·78	0·60	0·86 to 0·65	0·62 to 0·50
490 to 590	0·53	0·48	0·65 to 0·48	0·50 to 0·44
Over 590	0·42	0·42	*0·48 to 0·34	*0·44 to 0·34

* At 900 ft.

Comparing these tables it will be seen that: (*a*) The requirements throughout were at least as exacting—and in the majority of cases more exacting—than German practice; and (*b*) whatever the length of the vessel, whereas the maximum German requirement was 0·42 or a good two-compartment standard with a 16 per cent. margin, yet for vessels over 590 ft. in length the Convention gradually increased the sub-division up to nearly a three-compartment standard at 900 ft.

As regards the cargo passenger service, it might be said at first glance that there was fairly close agreement—but the figure shows that owing to the grading of the German regulations, vessels between 400 ft. and 500 ft. in length are severely affected, and it is vessels of such lengths that are most concerned in the cargo-passenger service.

A large amount of research work has been carried out in Great Britain to attempt to achieve a reasonable balance between safety and economic requirements, and the International Committee, with full knowledge of this work, laid down certain broad conclusions: (*a*) For vessels which may be described as "full-passenger," the curve C of the Convention should be adhered to up to 550 ft. in length, after which safety requirements were reasonably met by the provision of a two-compartment standard with a 10 per cent. margin, *i.e.*, a factor of sub-division of 0·45; (*b*) for vessels carrying mainly cargo with a small or "nominal" number of passengers, the curve B was too exacting and should be adjusted so as to provide a length of cargo hold of 80 ft. in the forward part of the vessel for ships of about 440 ft. in length and over*; (*c*) the "Criterion of Service," which measures the passenger function of the ship should be based upon†: (i) the permeability of the vessel below the bulkhead deck, subject to;

* German opinion considered their trades did not require so great a length as 80 ft. Japan required over 80 ft.

† The French members dissented entirely from this definition.

(ii) a correcting factor based on the total number of passengers carried, in order to take account of the variation in space allowance per passenger and in the distribution of accommodation; (iii) the correcting factor should be derived from a standard allowance—called "specific volume"—per passenger; (iv) where the total number of passengers multiplied by the specific volume per passenger exceeded the volume set apart for passengers below the bulkhead deck, then the criterion was to be determined by the total "specific volume" of the passengers; (v) that a vessel which did not carry more than $\frac{L2}{1,000}$ passengers should only be required to comply with the curve B1 after adjustment (L being the length of the vessel in feet); (vi) that vessels carrying more than $\frac{L2}{1,000}$ passengers should comply with requirements intermediate between curves B1 and C, in proportion to the actual value of the criterion of service; (vii) for the curves B1 and C the criterion values shall be constant, and preferably the difference in criterion value for curve B1 and curve C shall be so adjusted as to be 100; (*d*) that the bows of vessels shall receive additional sub-division varying from a two-compartment for the first two bow compartments to a three-compartment standard for the first three compartments, as the length and passenger service increases.

The committee made other recommendations with the hope of obtaining simplicity and equality of treatment; and it felt that it would be possible in the future to achieve greater ease of determination with equal accuracy of comparative treatment. The results of the work of this committee have also been published, and are under consideration by the British Board of Trade, who are likely to come to a decision very shortly after interviews with the British representatives of the International Committee dealing with the subject.

Future Work.—This very short account of the work of these International Committees is not by any means complete, nor is it possible to say anything about the labours of the committee which dealt with life-saving appliances and wireless telegraphy—both of which have been examined and to some extent adopted by the British Board of Trade. But this account, short as it is, does record a great advance towards international understanding between the nations engaged in world maritime trade, and it may be interesting to recount some of the experiences gained at the various meetings.

As a general rule, it was found preferable to discuss the subject under consideration in its historical aspect, and to use as the basis for discussion the latest pronouncements and investigations which were available. Various representatives would then recount their experience in the particular phase of sea activity under consideration, and would indicate the directions in which regulations were unduly restrictive and in which new or further regulations should be made, having due regard to economic requirements. In short, an endeavour was made to formulate a proper standard for the safe conduct of maritime transportation constituting the committee, and later to embody this standard of conduct in such regulations as could be administered by the competent authorities.

The next step in procedure which has been adopted by the British representatives is to place the reports and proposed regulations before the Board of Trade, with the endeavour to obtain immediate adoption of these regulations. It is understood, also, that a similar course is being followed in other countries, and already in Sweden and Denmark the Governments have to some extent adopted the recommendations of the committee which dealt with deck cargoes of light wood goods.

It must not, of course, be forgotten in framing these regulations that the civil laws of the various countries involved are to some extent and in certain directions founded on somewhat different bases, and probably the greatest difficulty in the way of the general acceptance of the reports of the various committees will be the necessity for some co-ordination of the civil law of the nations where these civil laws do not at present accord with the principles which have been found essential for the safe conduct of sea transport.

There is a further difficulty which can no doubt be overcome by the adoption of a suitable procedure during the interregnum period in which the new regulations are being substituted for the old, and that is in regard to the application of the new rules to old vessels. It will, of course, be argued that if new vessels are allowed concessions in any particular direction, such concessions would equally apply to old vessels. It will, of course, be admitted that it is easier to take account of additional restrictions in new ships; but it will certainly be argued that such are unnecessary to old vessels, seeing that they have proved themselves always, and in every way, satisfactory. It must not, however, be forgotten that in any straightening out process such as has been followed by the various committees to whose work reference has been made, there must, of necessity, be some penalties as well as some concessions if the general average of sea experience is to be maintained, because, as everyone knows, concessions for various reasons have been made from time to time in different directions.

It will be seen, as already stated, that the work which has been carried out is of fundamental importance to the world in general. What, in effect, is being attempted is to remove all possible misunderstanding among these engaged in overseas international trade, and thus to afford equality of opportunity for all sea traders, irrespective of flag, so long as the regulations accepted by universal agreement are complied with by all engaged in that trade.

The procedure which might be followed in all such attempts at self-government within the industry is for a Convention to be accepted internationally and its provisions included in the civil law of each of the contracting nations. In that way the sea trader who violates the international agreement will be liable in the civil courts. But even should it not be possible to arrive at an International Convention, or should any countries deliberately abstain from participating in the agreement, in the hope that their sea traders may reap an advantage, yet inevitably and in the long run those who do not conform to the agreed standard of sea conduct will find themselves shut out of international trade by the inexorable working of economic and commercial forces.

The sea industry is therefore making a wise endeavour to discipline itself, and the general acceptance by the many nations which took part in this work of the regulations to which they have agreed will be a milestone in the progress towards that universal understanding which lies at the root of world stability. And no record would be complete without an appreciation of the high spirit and lofty purpose which animated those who took part in this work—the mere drawing up of regulations is one thing; the spirit to carry them into operation is the essential thing.

CONTROL OF STEAM-PIPE LINES.*

Sectionalisation and Remote Control of High-pressure Steam Lines.

By PETER PAYNE DEAN, Stamford, Conn.

THE increase in steam pressure and temperature carried by modern central-station piping systems, and the necessity of placing control valves in inaccessible locations, the author believes, make a discussion of the best methods of steam-line protection and operation most opportune. With this in mind, he presents his views as to methods that have been already adopted in a number of large plants, and further explains the construction of various protective devices, valves, and motor-control systems that may be readily obtained in the open market to-day. Since reliable information pertaining to line fractures, operation of protective devices, and the like, is very meagre, the author trusts that in the discussion of the paper members will present their views on these important subjects.

This paper is intended to bring out need of protection other than that of hand-operated valves for high-pressure steam lines in case of failure of pipe or fittings, and deals with the remote operation of various types of valves by electric motor or steam piston in order to quickly and safely stop escaping steam. It is based on a very careful study of valve construction and methods of power operation made by the author during the last few years, and on experience gained with more than a thousand electrically operated valve installations which he has designed and placed in practically all of the large power-generating stations in the country. Steam pressures as high as 350 lb. per square inch with 700 deg. F. total heat are now frequently encountered, and no doubt 500 lb. will soon be standard practice. Under such pressures every piece of valve, piping, and fitting metal will be subjected to an excessive strain, which, when coupled with high temperature, may produce a result akin to metal fatigue, about which we have very little knowledge and even less experience. Further, no safe standard has been universally adopted for 500-lb. steam fittings, bolts, flanges, expansion loops, &c., but this will very probably come after more exhaustive time tests. The protection of human life, however, should be the first consideration, and after that, continuity of plant operation and protection of property; and surely all will agree that protection beyond that found in the average plant is necessary. We never think of asking an operator to manually trip an oil switch, which is done from the central switchboard; therefore, why ask him to mount a boiler or scramble through dark galleries to shut off a steam break when it may be done from a safe point by merely turning a switch.

We can only make every attempt to prevent failure by careful design, and then provide, as a matter of precaution, the best possible safeguard if it does happen. Those who were present at the tests made at the Essex power station of the Public Service Company, Newark, N.J., on January 28, 1922, and watched the spectacle of high-pressure steam calmly blowing to atmosphere at a velocity of over six miles a minute, do not need to draw much upon their imaginations to visualise the damage that such a discharge would be in a boiler or turbine room.

Location of Master Valves.—The master valves should be those nearest the boiler, with either the automatic stop checks or gate valves in the boiler lead. Valves at this point protect the complete piping system and would not be affected by mechanical movement of a broken line, which would possibly throw excessive strain on a gate valve, causing it to jam. Automatic stop-check and boiler-lead gate valves are seldom above 10 in. in diameter and without doubt can be closed in from 15 to 30 seconds, so that any or all of the boilers may be cut out at will. Unless all the boilers are isolated there would be a reverse flow from the header back through the break, so that a master valve is also necessary in the boiler lead at the header, which in any event is usually included. Closing both the boiler-lead valve and this last-mentioned valve completely isolates one boiler. Boiler-lead valves are suggested for three very good reasons:

(*a*) They protect the whole system of piping from the superheater and are well located for power operation.

(*b*) If a bad fracture should occur, it would be almost useless to endeavour to locate it and sectionalise the header to stop the flow, on account of the tremendous volume of condensed steam and consequent confusion.

(*c*) There is no certainty whatever that header valves above 12 or 14 in. in diameter will close under open-end conditions on account of their construction to withstand such strain.

The principal argument against emergency closing off of the boilers is that the plant would be completely shut down. In the author's opinion, if a bad break occurs its location cannot be determined until almost the entire steam supply is stopped. As soon as the break is located, the sectionalising valves may be brought into play and the boilers quickly brought back on the line.

Even though large header valves can be closed from a distance, the author nevertheless believes that the quick and safe way is to shut off the boilers in sections until the break is stopped. Incidentally, with any remote-closing scheme the boiler safety valves should be piped to a header and blown to atmosphere, as in the event of a boiler shutdown they would all blow together. Some arrangement also of an auxiliary header should be worked out to supply the boiler-feed pumps, as well as a scheme for shutting down the draft fans. Power-operated header valves of large diameter may be depended upon to stop a very bad fitting blow or gasket leak, so for this reason and also for convenience of operation they should be provided with remote control.

To close an 18-in. high-pressure gate valve requires two men for a period of at least 15 minutes, including transit to and from the valve, not to mention the physical effort necessary and the danger of penetrating a steam-laden alley with very uncertain conditions under foot. For years engineers have applied power operation to sash monitors, ash gate dampers, and other auxiliaries, but seem to have entirely overlooked the poor old steel sentinel that stands guard over the main artery. Great care is taken to see that main-line valves are tested for tightness and that they are strong and rugged, presumably for assurance that they will not fail during operation or when an emergency arises. Who knows, however, whether they can be even reached in case of trouble? Therefore, why not turn them into real protective devices by providing remote control? It should not take much of an argument to convince those in charge of expenditures that it is worth the money. Fig. 1 shows a typical existing boiler and piping layout in which electrically operated valves are employed. Complete isolation of one boiler from the line may be made by closing any pair of valves *A*, *B*, either singly or from one switch, but this of course leaves the boiler-lead lines unprotected. Further protection may be accomplished by electrically operating the non-return valves shown and closing them together with valves *A*, *B*, in order to prevent reverse flow from the header. Fig. 2 shows a similar system wherein the boiler-lead valves may be closed separately and the main- and branch-header valves used for sectionalising.

Remote-control Location.—Since any remote-control system must of necessity be electrical, the design and placing of a central switchboard must be carefully thought out. The location should be as near the main means of exit as possible, as plant operators in case of trouble will move toward this point. With the open air in view, a man is more apt to regain his composure and presence of mind than when called upon to act hurriedly and then bolt for his life. Such stations should never be placed in steamproof vaults adjacent to the boiler room and without means of safe exit. They will be useless in emergencies as the operators will not travel in that direction.

The operation of switches to shut the valves should be as simple as possible, preferably by breaking a protective glass window and pushing a button. Under no consideration is it safe to open master valves from a remote point which may be opened locally, either by hand or electrically. In order to allow the operator to see exactly what he is doing, the face of the valve control switchboard should be provided with a plainly marked miniature representation of the complete station piping as shown in Fig. 3, with push buttons to represent the valves. Red and green indicating lights should be provided to show whether the valves respond and to indicate the general position of the valves in the complete system.

Types of Master Valves.—There are two types of quick-acting valves, the straight triple-duty and the piston-operated trip valve, both of which are of the globe type. The former is a combination of non-return, stop, and "automatic closing on drop of line pressure," performing therefore the three duties. Engineers have not taken kindly to line protection upon drop of pressure; therefore the third duty is operated by an electrically controlled pilot valve admitting steam on top of the closing cylinder. Such a valve and its auxiliary pilots are shown in Fig. 4. This valve depends upon the excess-area piston forcing the disc to its seat against the pressure. The straight trip valve closes with the pressure and is remotely operated by a solenoid magnetic latch. This valve is used mostly as an additional emergency turbine stop upon overspeeding, being placed in the turbine lead between the header and throttle trip valve. On account of its somewhat complicated construction, it is hardly suitable for line protection. The triple-duty remotely controlled valve would seem to be the logical type for quick closing, provided that it can be made to close against the extreme velocity which would result with an open-end line blowing to atmosphere and would possibly reach 50,000 ft. per minute, depending upon the friction loss in the pipe between the header and the boiler. The action in this case would not be that of a non-return automatic check valve which actually closes due to the reverse flow, but the disc would be forced on to its seat against an extreme velocity in the opposite direction and the action would be somewhat akin to that of stopping a high-pressure nozzle

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with one's finger. Valves of this description are generally closed by pressure being admitted to the top of the excess-area piston, but test data on closing under extreme velocity conditions do not seem to be available and until they are, much cannot be said.

A high steam discharge is very apt to carry over slugs of water, and there may be some doubt as to the advisability of instantly closing a valve under this condition. It would seem that a closing time of 10 to 15 seconds would be safer.

Motor-operated Non-return Valves.—Electrical operation of non-return valves was first suggested by the author and has been adopted by many leading engineers. The operation is the same as that required on the triple-duty design, with the exception that the valve stem is driven by a motor provided with reduction gearing, as shown in Figs. 5 and 6. Their action under most extreme conditions is positive, provided that the motor control is of the proper design and application. The valves are ideally located with respect to line protection, being directly at the superheater outlet and where vibration due to the whip of a broken boiler lead would not be excessive on account of the valve being securely anchored. They close easily under normal conditions, and for emergency closing should be provided with ball thrust bearings to eliminate the closing friction as much as possible. The control unit should be bolted directly to the yoke and geared to the stem through the yoke nut which is of the rising-stem type. The travel of the disc is not more than one-quarter of its diameter, so that quick closing is possible. Although ruggedly built this valve will not stand much jamming, and therefore calls for a special type of motor control to prevent it.

There is only one safe point of closing, and that is when the discs and seats are in perfect contact; to effect this the motor drive should have an automatically operated mechanical clutch completely disconnecting the high-speed armature and gears from the motor at the moment of closing, thus eliminating its momentum and allowing the motor armature to come freely to rest. Without this clutch the limit switch must be set to stop the motor before the valve reaches its seat, and a certain amount of drift due to the momentum of the armature and gears must be depended upon to seat the valve. This drift depends upon the resistance to closing, which distinctly varies with line conditions; for instance, when the valve is closed with balanced pressure and there is no flow in the boiler-lead line, there is no resistance to the disc, and the electrical limit must be set to trip just at the point of closing so that the disc can drift into its seat.

Assume, then, an open-end pipe condition with steam blowing to atmosphere, during which the disc encounters excessive resistance. The moment the electrical limit opens, the velocity will overcome the momentum and act as a brake, thus causing the motor to stop instantly and before the valve is actually seated.

The non-return or globe valve must seat tightly and has no leeway to travel as has a gate valve. Therefore it should be made to seat tightly under all conditions and without jamming or strain.

Types of Gate Valves.—The Essex station tests showed that valves of this description up to 10 in. in diameter may be safely closed under emergency conditions, and from a careful study of their behaviour it seems safe to recommend them for line protection up to 12 and 14 in. in diameter. Data on emergency closing of valves of above this size and up to 22 in. are not available and the safest construction would be to machine the guides, provide the yokes with ball bearings, and attach a control unit of extra large capacity. Valves of this size are used generally for line sectionalising, and no attempt should be made to close them quickly. A typical electrically operated boiler-lead valve is shown in Fig. 6. Table I shows the speeds of closing recommended under various conditions that have been standardised by most of the valve manufacturers.

For emergency closing with an unknown direction of steam flow in the line, there seems to be little choice as to the type of gate-valve construction between the solid-wedge taper seat, the split-wedge taper seat, and the parallel-seat Hopkinson type. A valve of each type was tested at Essex station and examination showed that none of them was excessively affected by the strain.

For steam lines with one direction of flow, such as boiler and turbine leads, the Borsig type is particularly

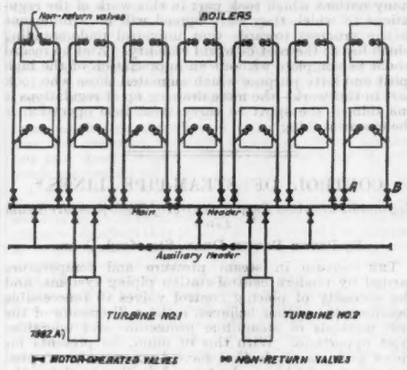


FIG. 1. BOILER AND PIPING LAYOUT OF A POWER STATION IN WHICH ELECTRICALLY OPERATED VALVES ARE EMPLOYED.

(Colfax Station, Duquesne Light and Power Company, Pittsburgh, Pa.)

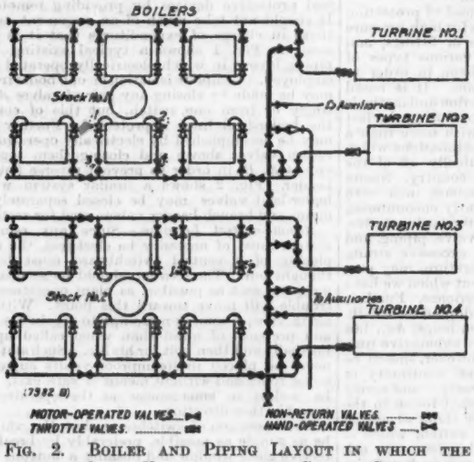


FIG. 2. BOILER AND PIPING LAYOUT IN WHICH THE BOILER-LEAD VALVES MAY BE CLOSED SEPARATELY AND THE HEADER VALVES USED FOR SECTIONALISING.

(Hell Gate Station, United Electric Light and Power Company, New York.)

Motor Control.—There is hardly a piece of machinery in the power plant that is subjected to such extreme operating conditions as the motor-controlled valve:

(*a*) It is usually located in an out-of-the-way gallery and covered with coal dust, and in a temperature ranging between 150 and 165 deg. F., which necessitates special heatproof motor-coil insulation.

(*b*) It is thrown directly across the line without the aid of starting resistance so that the full voltage is impressed upon the windings, and at the same moment the motor may be called upon to exert its maximum mechanical effort in unseating a tightly seated valve.

(*c*) It must be small and compact, automatically lubricated, and entirely steamproof and waterproof.

(*d*) Periods of inoperation range from a minimum of one week to, say, three months, during which time plant conditions may be such as to prevent its operation; and it is expected to function perfectly, even though it has not been tested over this extended period.

(*e*) Steam from a leaky gland may be allowed to blow freely on the control unit for an indefinite period, and to withstand this it must be impregnated.

(*f*) In case of piping rupture it is more than likely to be enveloped in condensed steam, and just at this time it will be called upon to exert its maximum mechanical effort to close the valve.

The duty on such equipment is extremely severe and without doubt necessitates much special construction. The motor must be of the totally enclosed type and provided with ball bearings of excessive diameter. It should be bolted directly to the reduction-gear casing, leaving no coupling or high-speed shafts and bearings exposed. It should be series wound with such characteristics that it will automatically slow down upon the application of load caused by the valve disc passing into the seat. This is the surest means of protection against cutting of the disc and seat rings. The reduction gears should be of heat-treated steel on account of their compactness and the excessive strain that may be applied, and should be continually immersed in oil. Any oil-less or self-lubricating type of bearing for either

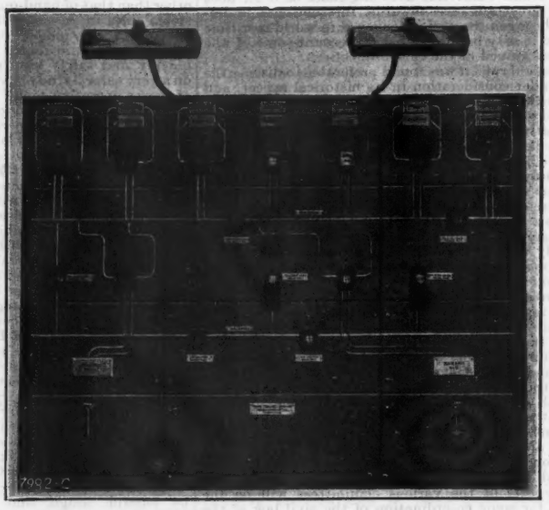


FIG. 3. MINIATURE REPRESENTATION OF COMPLETE STATION PIPING MOUNTED ON FACE OF VALVE-CONTROL SWITCHBOARD.

well adapted as the steam flow assists in closing, and against a minimum of friction. It has the advantage of minimum pressure drop on account of the straight opening and may be quickly closed by motor operation up to large diameters. The motor-control apparatus need be only of sufficient capacity to open the valve under balanced conditions. This type is used extensively abroad in place of globe valves, and a 6-in. Borsig valve that was tested at the Essex station operated satisfactorily under emergency conditions.

TABLE I.—*Speeds recommended for Closing High-pressure Steam Valves under Various Conditions.*

(Based on valves provided with ball bearings, and machined guides. Maximum steam pressure, 350 lb. per square inch.)

Gate Valves (under emergency conditions, full blow to atmosphere):—							
Size, inches	4	6	8	10	12	14
Type of Dean unit used	M3	M3	E1	E2	E2	E2
Closing time, seconds ...	20	30	30	30	45	60
Gates Valves (under normal operating conditions, steam velocity not exceeding 15,000 ft. per minute):—						
Size, inches	16	18	...	...	...	...
Type of Dean unit used	E2	E2	...	...	...	...
Closing time, minutes ...	2	3	...	...	...	...
Automatic Stop and Check Valves and Globe Valves (emergency conditions):—						
Size, inches	6	8	10	12*	14*	...
Type of Dean unit used	M3	E1	E2	E2	E2	...
Closing time, seconds ...	30	30	30	45	60	...

* Closes with pressure.

the motor or slow-speed shaft should be avoided on account of its inability to withstand excessive heat, long periods of rest, and the accumulation of dust in the bearing.

On account of the excessive drift of the motor armature and gears after tripping, a declutching device should be provided to enable the valve stem to be stopped automatically at a predetermined point without jamming. In the same casing should be provided a self-contained electrical limit which is capable of breaking the main motor current without arcing and so geared that operation of the valve by hand will not throw it out of adjustment. The casing should be provided with one conduit opening arranged for making a steamproof joint between the internal connections and the line, and all internal connections should be of asbestos-covered heatproof cable. Control of the valves may be effected from either one point or from multiple points by the aid of a totally enclosed dustproof reversible drum switch capable of reversing the armature connections.

The stations should be provided with lamp indication showing the full open and closed positions of the valve at all times. Such a control switch should be provided with a lock, an emergency glass window, and a hammer. For multi-point control an interlocking system should be provided so that the first operator to reach a valve will have full control, even though other control stations are operated at the same time and in reverse directions. The best way of accomplishing this is to provide an interlocking relay panel so that only one switch may be closed at a time, and further protection by an electrical interlock consisting of a magnetic system whereby each control-station

drum will be retained in its proper operating position and will automatically return to the "off" position at the opening or closing point of the valve.

In every case both poles of the electrical circuit should be interrupted when the switches are in the "off" position. Single-pole break is dangerous, as a ground may cause the valve to either open or close and produce very serious inconvenience.

Voltage.—A valve-control system should be connected to the most reliable source of current in the station, which is either the direct-current exciter or switch-control battery circuit, as it is equal in importance to any piece of auxiliary machinery. The voltage should not exceed 250, firstly, because direct-current battery circuits of this voltage are standard, and secondly, because higher voltages would cause an unnecessary strain on the very closely packed windings. Valve motors are thrown directly across the line without resistance and encounter at the same moment their full mechanical strain due to a tightly seated valve.

Control-Station Location.—Each valve should be provided with a local control station, mounted at some point from which opening and closing the valve may be observed. Preferably there should be two points of control for each valve, one in the boiler room close to the door leading into the turbine room, and the other at a safe point unlikely to be affected by steam flow. Where a centralised control board is adopted, the second point of control may be mounted in the turbine room, and for the closing of turbine-lead valves the control may be mounted on the turbine gauge board.

Conduit and Cable.—All conductors should be suitably protected by fuses having a capacity equal to the full-load starting current of the motor, and fuses rather than switches should be provided for disconnection. The cable should be chosen according to the location, and for the operation of high-pressure superheated-steam equipment, should have an asbestos heatproof covering.

It is a good plan to end the rigid conduit within 3 ft. or so of the control unit, and from that point use a flexible loop of Greenfield or similar duct. This will allow considerable vibration in the pipe line without affecting the cables, and will further enable the control unit to be freely moved.

Hand Operation.—Handwheels should be provided in case of failure of current supply. No declutching device should be installed between the motor and valve which destroys the relative position of valve and motor mechanism. A properly designed and cared-for valve-operating system, especially in a power plant, need never fail, and in case of possible failure at a critical moment the valve may be closed by the handwheel, through the gears and motor, in almost as short a time as when the parts are disconnected. The great danger of a declutching device is that it is very apt to be left disconnected with no means of showing its position at the control station, and that it introduces a non-foolproof feature by providing a piece of mechanism that can be tampered with by any unauthorised person. If such a device is insisted upon, it should be a self-contained part of the mechanism and operated externally by the aid of a wrench. Further, it must be so arranged that positive indication of its position must be noted on the indicating lights at the control station.

Periodic Tests.—Every electrically operated valve should be opened and closed at least once a week, preferably under load conditions if possible, and an examination of the internal parts should be made at least once a month and all records of such tests and examinations kept on file.

The Author's Control System.—The Dean control system of valve operation was designed exclusively for the operation of valves, and since it embodies all the features that have been enumerated, only a brief description of its mechanical operation will be given. The Dean type E unit consists of a driving motor, reduction gears, and limit trip mechanism mounted in a single case. The feet of the unit are provided with four holding-bolt holes of standard dimensions for a given range of valves. Four standard units cover the complete line of valve sizes in use.

The motor is totally enclosed and steamproof, and possesses an extremely high torque. It is connected to a system of combination worm and planetary gearing for the necessary reduction in speed. The motor speed is normally 1,600 r.p.m. and that of the slow speed shaft

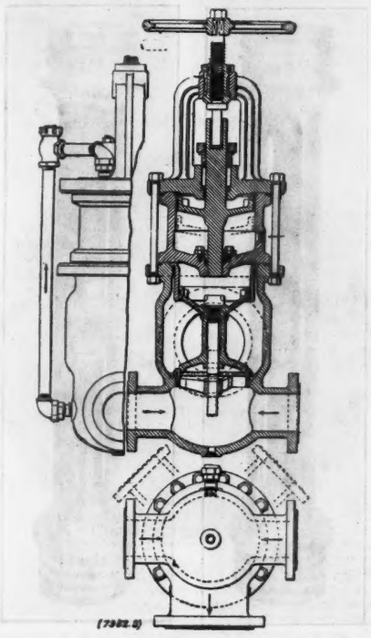


FIG. 4. CROSS-SECTION OF AN EMERGENCY PISTON-OPERATED STEAM STOP VALVE.

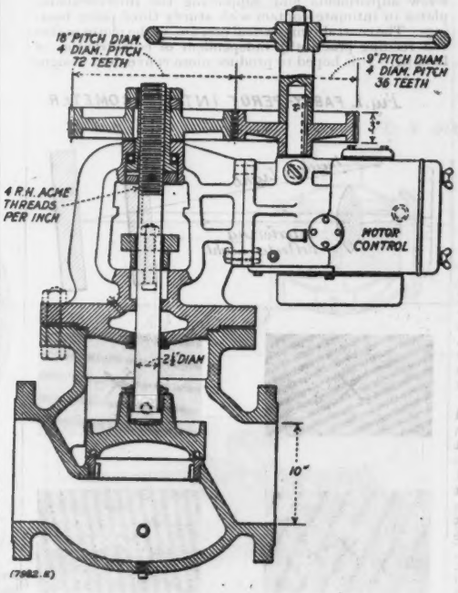


FIG. 5. CROSS-SECTION OF AN ELECTRICALLY OPERATED GLOBE VALVE PROVIDED WITH BALL THRUST BEARINGS.

FIG. 6. TYPICAL ELECTRICALLY OPERATED BOILER-LEAD VALVE.

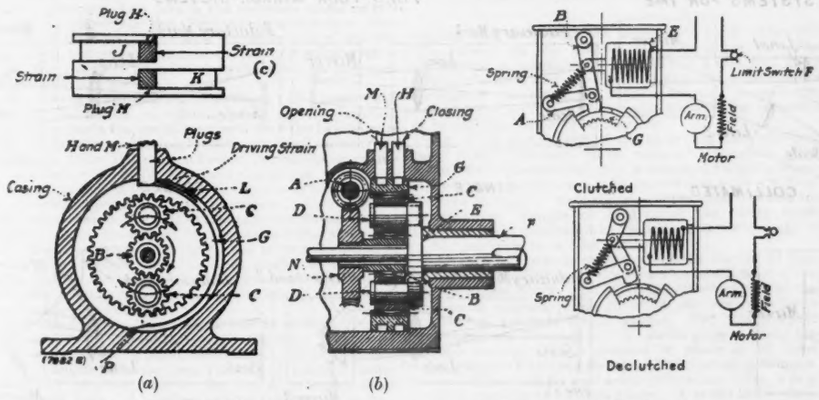


FIG. 7.

FIG. 7. MECHANISM OF ONE TYPE OF THE AUTHOR'S VALVE-CONTROL UNIT.

FIG. 8.

FIG. 8. SKETCH SHOWING PRINCIPLE OF OPERATION OF A SECOND TYPE OF VALVE-CONTROL UNIT.

40 r.p.m., the gear reduction being 40 to 1. The motor shaft is coupled to the worm shaft A (see Fig. 7), both running in ball bearings, and the worm wheel N is keyed to a sleeve forming the sun pinion B of a planetary gear. The planet pinions C revolve on large studs D forced into a flange E forming part of the slow-speed driving shaft F, and these pinions mesh into the internal gear G forming the outer member of the planetary gear. Fig. 7 (*a*) shows the assembly of the planetary gear, the external member or internal gear of which is marked G. The centre or sun pinion B is caused to revolve by the motor, and this pinion turns the planetary pinions C and shaft F in the direction shown. The outer member or internal gear G is free to revolve on a machined surface in the casing, but is restrained from doing so by two plugs M and H which also pass through the casing as shown. Fig. 7 (*c*) shows another view of the outside surface of the internal gear G, and it will be seen that this surface is provided with two peripheral channels, one extending half-way around in one direction as shown at J, and the other in the opposite direction as at K. When both plugs H and M are in, or in the locked position, the internal gear G cannot move; therefore, with the sun pinion being driven by the motor, the planetary pinions must turn on their own axes and travel around the internal gear, thus also moving the flange E and drive shaft F. Referring again to Fig. 7 (*a*), let it be assumed that the valve is closing and the plug H is restraining the movement of the internal gear which tends to move in the direction indicated by the arrow L. At a predetermined moment when the valve is tightly closed, but not jammed, this plug is quickly withdrawn from the slot by a special cam movement, and since there is no friction now restraining the movement of the internal gear, it is of course free to revolve in the direction shown.

At the precise moment of withdrawing the plug the electrical circuit is interrupted by the limit switch, and the drift of the motor coming to rest is taken by the internal gear revolving in its casing. Experiments and practice tend to show that the motor comes to rest after the internal gear has travelled about half a revolution. Should any further drift take place, the plug M is automatically moved upward by the moving tapered stop P in the groove, which operation does not open the electrical limit. It will be noted that the plug is still in the other slot. During the opening of the valve the motor will of course be reversed, and the internal gear will have to revolve in the opposite direction before the plug M comes in contact with the stop. This provides a hammer blow which is sometimes necessary to open a tightly seated valve, but by no means essential as the motor has sufficient torque to operate the valve under all conditions. It is easily seen that the moment one of the plugs is withdrawn the slow-speed drive shaft stops instantly, and that it can only stop at

exactly the same point during every operation irrespective of load or friction. Thus the valve gate is never jammed. The valve gate is made to seat tightly, under power, and to a predetermined point, drift and overtravel being disregarded as a means to this end.

Tachometer readings show that at the moment after tripping, the motor armature speeds up considerably before the electrical limit contact is broken, which indicates that the load is released prior to the interruption of the circuit, thus eliminating arcing. The gearing for speed reduction is encased in a cast-iron housing partly filled with oil, so that the gears are always well lubricated. The limit mechanism is contained in a separate part of the housing and provided with a removable cover.

The type M or magnetically operated improved Dean system shown in Fig. 8 is very similar to the type E design with the exception of an improved limit and method of releasing the restraining plugs. In place of the plugs H and M as shown in Fig. 7 (*b*), a restraining pawl A is provided which is held in the operating position by an energised magnet E connected in the main electrical circuit. At the moment the electrical limit switch trips at the end of travel, the spring-operated toggle B is broken and the restraining pawl A instantly releases, allowing the internal gear G to revolve freely and take the complete drift of the motor armature. A very noteworthy feature in this design is that the handwheel is always free to operate without the necessity of employing a declutching device.

OPTICAL STRAIN GAUGES AND EXTENSOMETERS.*

By L. B. Tuckerman, United States Bureau of Standards.

For many years optical methods have furnished the most sensitive and most accurate means of measuring small distances, including small displacements or deformations. For this reason they have been chosen where extreme sensibility or extreme accuracy was desired. The Martens extensometer† was heretofore the most precise extensometer in common use, and the interference method of Peters‡ has been the most accurate method of checking precision gauges.

Unfortunately, optical devices, although precise and sensitive, have been cumbersome and difficult to maintain in adjustment. This has limited their usefulness in great measure, confining them largely to well-equipped laboratories with a highly-trained personnel.

A study of optical methods of length measurement for the purpose of making them conveniently usable under ordinary conditions has led to the development of the new optical devices here described, which are free from many of the disadvantages of the older types.

Two optical methods are conveniently available, interference methods and the optical lever. The use of a microscope, as in the Ewing extensometer, might also be called an optical method, but the principal of the instrument is mechanical, the microscope being used solely to make the displacements conveniently readable. Possibly the accidental double refraction of transparent materials under stress, discovered by Brewster,§ applied by Maxwell‖ to the study of plane stress, and recently brought again into prominence in "optical stress analysis," might also be used, but there seems to be no likelihood that it will ever be used in a strain gauge or extensometer.

Interference Methods.

Interference methods have the advantage that they carry their own calibration with them. This makes them useful in standardisation. Except in very limited fields, however, the tediousness of counting bands excludes them from common use. Fig. 1 shows the principle of the Fabry-Perot* interferometer, by which measurement is easily possible to $\frac{1}{40}$ wave-length of the light used, approximately to $\frac{1}{2,000,000}$ in. The incoming beam of light is reflected at two nearly parallel surfaces. In Fig. 2 is shown a Fabry-Perot interferometer in the form of an interferometer dynamometer of rugged construction developed in collaboration with Mr. C. G. Peters of the United States Bureau of Standards. It is so designed that it will maintain its adjustment unchanged under a very rough handling. The instrument can be pounded with a hammer or even dropped a foot or so on to a wooden floor with no perceptible change of its reading. This ruggedness has been obtained by machining the dynamometer from a single solid piece, eliminating all screw adjustments and supporting the interferometer plates in intimate contact with sturdy three-point bearings. The central symmetrical position of the plates makes the reading practically independent of eccentricities of loading. It is hoped to produce more convenient designs by introducing wrench-fitting screw joints in strain-free positions. This possibility has not yet been tried out.

If the light from a helium lamp reflected from this instrument is viewed through a Pulfrich spectral system,† the field is crossed by interference bands as seen in the typical fields, Fig. 3. The reading consists in counting the bands as they pass the fiduciary mark (in the form of a cross). During this passage the bands narrow and widen and shift through all points of the compass, due to unavoidable small changes in the eccentricity of the applied load, but the symmetrical arrangement of the plates and the fiduciary mark makes the number of the band on the mark an accurate measure of the average stretch of the dynamometer. As the total range of this instrument is approximately 1,000 bands and readings can readily be made to $\frac{1}{10}$ of a band, the instrument is obviously extremely sensitive. Its constancy, however, has not been fully checked. It is more constant in reading than the testing machines with which it has been compared. It is planned to make a complete check on the constancy in a dead weight machine now under construction. The usefulness of this instrument is much limited by its sensitiveness to vibration. Heavy running machinery in the neighbourhood sets up vibration sufficient to obliterate the bands completely.

The Optical Lever.

Observing Systems.—In Fig. 4 are shown three types of observing systems for the optical lever. The first is the uncollimated system in common use to-day—either as telescope and scale or as lamp and scale. Its disadvantages are well known, any relative shift of fiduciary mark, scale, lens or mirror may change not only the reading of the instrument, but also its calibration. Any one who has had the misfortune to have a partially completed series of readings made valueless by an inadvertent disturbance of such a system will realise fully how great a disadvantage this is.

The second is a collimated system. Here the calibration of the instrument depends solely on the focal lengths of the two lenses and their proper collimation. These can easily be made of rugged construction so that only extreme abuse will alter their adjustment. The reading will depend only on the relative direction of the two collimators (or collimator and telescope) and the mirror.

The third is an auto-collimated system. Here the possibilities of disturbance are still further reduced. The calibration depends only on the focal length of the auto-collimator and its proper collimation. The reading will depend only on the relative direction of the auto-collimator and mirror.

Both collimated and auto-collimated systems have been used for a long time in many fields of optics. So

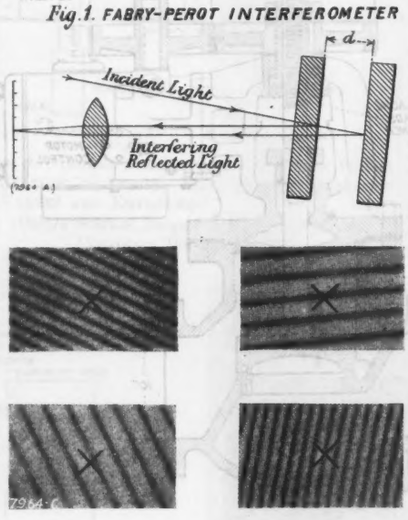


Fig. 3. Interference Bands as seen in Pulfrich Spectral System.

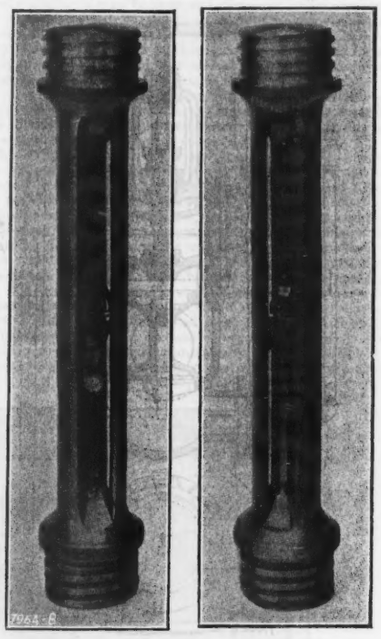
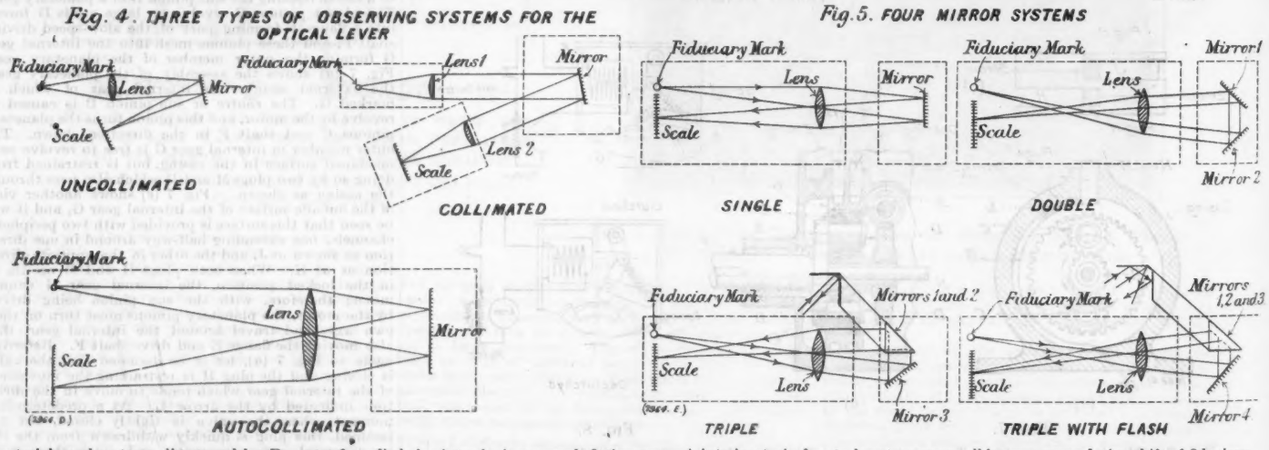


Fig. 2. Interferometer Dynamometer.



* Paper read before the American Society for Testing Materials, June 29, 1923.

† A. Martens, "Handbook of Testing Materials" (Translation by G. C. Henning, 1899), page 67.

‡ C. G. Peters and H. S. Boyd, United States Bureau of Standards Scientific Paper No. 936.

§ D. Brewster, Phil. Transactions Royal Soc., vol. cv, page 60 (1815).

‖ J. Clark Maxwell, Transactions Royal Soc., Edition 20, Part 1, 1850; Scientific Papers, vol. i, page 67.

* Fabry et Perot, *Annales de Chem. et Phys*, vol. xxii, page 564 (1901).

† Pulfrich, *Zeitschrift*, f. Inst. k., vol. xviii, page 261 (1898).

OPTICAL STRAIN GAUGES AND EXTENSOMETERS.

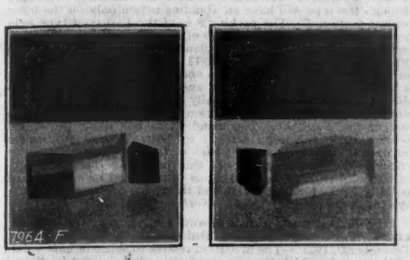


FIG. 6. PRISM SYSTEM.

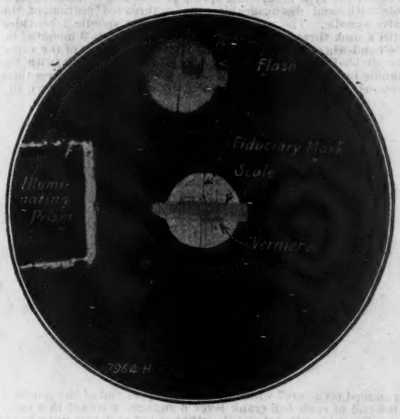


FIG. 8. OBSERVING FIELD OF AUTO-COLLIMATOR.

far as I knew they had not been applied to optical levers, but since this work was begun, Gehlhoff* has published a description of an auto-collimator adapted for use with an optical lever.

Mirror Systems.—The advantage of the auto-collimated observing system is so great that the mirror systems are all discussed in combination with an auto-collimated observing system. In Fig. 5 are shown four different mirror systems. The first is the common single mirror system as used on the Martens extensometer. The reading is intended to measure the extension of the test specimen, but every rotation of the observing system or of the specimen as a whole will alter and therefore vitiate the readings.

The second is a double mirror system. (This system was used by Gehlhoff). A reading taken in any direction perpendicular to the line of intersection of the two mirrors depends solely on the angle between the two mirrors. Deviation from the perpendicular introduces a cosine error which is negligible for small deviations.

The advantage of this system has long been known. Its most familiar application is in the sextant. Used with an auto-collimator it has a disadvantage not found in the sextant. Any deviation of the auto-collimator axis from the plane perpendicular to the mirror intersection moves the reflected light at right angles to the scale through double the angle. This does not appreciably alter the reading (the cosine error is small), but makes the reading more difficult.

The third is the new triple mirror system, finally adopted. Two mirrors are fixed together practically at right angles, and a third, relatively movable, is nearly at right angles to these two, its axis of rotation being practically perpendicular to the line of intersection of these fixed pairs. A reading can be taken from practically any position in front of the three mirrors, and the image of the fiduciary mark in the observing field is steady, even with a vibrating or rotating mirror system. There is, of course, a cosine error. This could be eliminated as in the use of the sextant by swinging the instrument to a maximum reading, but the fourth system was found more convenient, a small auxiliary mirror being used to convert it effectively into a combination of double and triple mirror systems, thus producing a "flash" as the collimator passes through the perpendicular position. Whenever the "flash" is within the field of view, the deviation from the perpendicular is so small that the cosine error is negligible.

For use with an auto-collimator the mirrors must have very accurately plane surfaces. These are more easily obtained in prisms than in ordinary plane mirrors. Fig. 6 shows two views of the prism system as constructed. It consists of an ordinary 45-deg. prism and a roof prism modified to give the "flash." Fig. 7 is a diagram of the auto-collimator, showing the illuminating lamp and prism, the reticule carrying the fiduciary mark,

*G. Gehlhoff, *Zeitschrift*, f. Tech. Phys., vol. iii, page 225 (1922).

Fig. 7. DIAGRAMMATIC SKETCH OF AUTO-COLLIMATOR

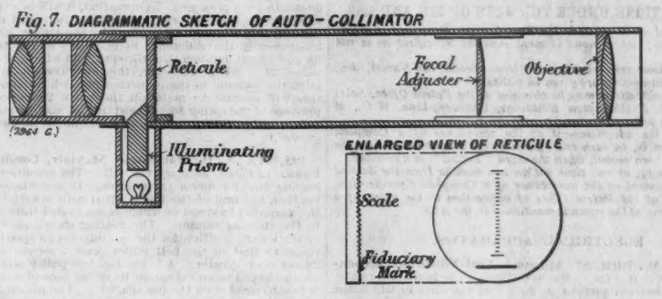
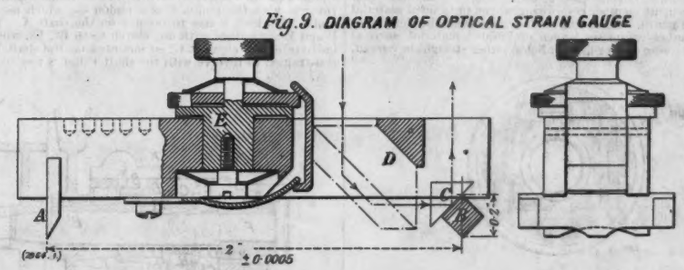


Fig. 9. DIAGRAM OF OPTICAL STRAIN GAUGE



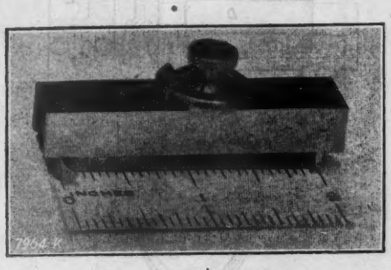


FIG. 10. OPTICAL STRAIN GAUGE.

vernier and scale, and the auxiliary "focal adjuster." The rulings on the reticule face the objective. The instrument is permanently adjusted to a standard focal length (25 cm.) and the bearing ring of the reticule is accurately machined to focus. By this means the reticules are made interchangeable without the necessity of re-collimation or re-calibration.

Fig. 8 is a photograph of the observing field, showing the "flash," fiduciary mark, vernier* and scale. The shape of the illuminated area is designed to make alignment of the vernier easy. In connection with a 0·2-in. Martens lozenge, 1 scale division represents 0·00004 in. deformation. Tenths of a division are easily read. The reticule is graduated to read elongations directly in inches per inch on a 2-in. gauge length.

The present instruments were built by the Naval Gun Factory for the Bureau of Construction and Repair of the United States Navy. An extended investigation of the stresses in riveted joints required the use of a large number of accurate strain gauges. For this purpose the prisms are mounted in 2-in. strain gauges, using the Martens lozenge. It is planned to place 30 of these strain gauges at various points on the riveted specimens. These will be read by two auto-collimators. Fig. 9 is a working drawing of a strain gauge. A is the knife-edge, B the lozenge carrying the 45-deg. prism C. D is the roof prism, which is adjusted by the double cam E, with coarse and fine adjustment, to bring the fiduciary mark to zero on the scale. Fig. 10 is a photograph of the strain gauge as constructed.

The sensibility of the system as constructed $\left(\frac{1}{250{,}000}\right.$ in.) is well above its possible limit. It may ultimately be possible by its use to measure strain conveniently and accurately on $\frac{1}{4}$-in. gauge lengths.

The optical system described, obviously has many possibilities of application. It is directly applicable to a wide variety of strain gauges and extensometers. On light specimens, such as thin sheet materials or wires where the weight of the extensometer is a controlling factor, it has obvious advantages. It is at present being adapted in the dynamometer laboratory of the United States Bureau of Standards to a torsion dynamometer for rotating shafts, and a number of other applications are contemplated.

*The use of the vernier was suggested by Lieutenant E. L. Gayhard, of the Construction Division of the United States Navy.

CATALOGUES.

Chemical Works Machinery.—We have received a sheet of illustrations of the machines and vessels specially constructed for the chemical trades by Messrs. Manlove, Alliott and Co., Limited, Nottingham.

Switch Gear.—Several sheets of illustrations of safety fuses and switch fittings have been sent to us by Mr. Frederick Pratt, 66, Victoria-street, London, S.W.1, amongst which is one on Vanwyck's patent overload switch.

Roller Bearings.—A list of roller bearings in all the standard forms of housings has been received from the Northampton Machinery Company, Limited, St. Michaels-road, Northampton, accompanied by a list of current prices.

Air Cleaning.—Several machines for filtering air, collecting and purifying waste gases, recovering zinc oxide, tea dust, &c., are described in a catalogue received from Mr. Albert E. Harris, 19, Russell-square, London, W.C.1.

Electric Contactor Gear.—A description of the standard forms of contactor and the formation of units into control panels, followed by a detailed and illustrated description of the various contactor apparatus produced by the company, is given in a special 16 pp. catalogue issued by the General Electric Company, Limited, Kingsway, London, W.C.2.

Air Compressors.—A single cylinder air-cooled air compressor displacing 17·5 cubic feet of air per minute and three sizes of two-cylinder water cooled air compressors displacing up to 210 cubic feet of air per minute are very fully described and illustrated in a catalogue received from the Consolidated Pneumatic Tool Company Limited, 170, Piccadilly, London, W.

CO_2 Tester.—A portable type of CO_2 tester by means of which a test can be performed in three minutes or less and which requires neither steam nor water connections, is described in a catalogue received from Messrs. Kelvin, Bottomley and Baird, Limited, 18, Cambridge-street, Glasgow. The instrument weighs only 4½ lbs. and is provided with a leather case for carrying.

Oil Engines.—A new edition of their catalogue of cold starting oil engines has been prepared by Messrs. Ruston and Hornsby, Limited, of Lincoln. They are of the vertical type and work on crude oil or the lowest grade of fuel oil, and solid injection is used with them. The range of power is from 55 b.h.p. to 825 b.h.p., the engines having from one to six cylinders. All the essential information regarding the construction of the engines is clearly specified.

Oil Well Engines.—A series of steam engines and boilers specially designed for use in drilling oil wells is the subject of a special catalogue received from Messrs. Marshall, Sons and Co., Limited, of Gainsborough. They are of the single expansion type in five sizes with cylinder diameters ranging from 10½ in. to 12½ in. and with 12 in. stroke, and also in two cylinder units with cylinders 11 by 14 in., 12 in. by 14 in. and 14 in. by 16 in. In addition three small engines of 6½, 9 and 10 b.h.p. are supplied mounted on boilers or separately. The boilers used for all sizes are of the multitubular type and mounted as portable or semi-portable sets. Oil burning appliances can be fitted to the boiler furnaces when desired. All parts of these oil well sets are made to limit gauges and are therefore interchangeable and have been designed to suit the rough conditions of the usual service.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

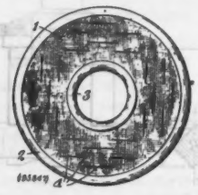
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

ELECTRICAL APPARATUS.

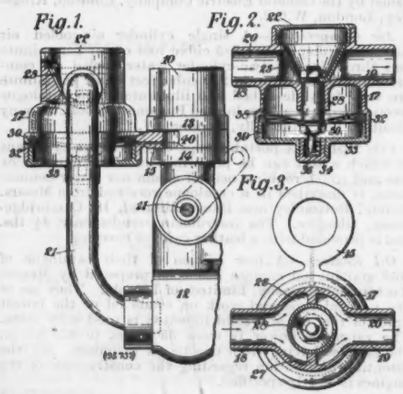
195,847. W. Bird, St. Albans. Anti-Vibration Suspension Devices. (6 *Figs.*) March 6, 1922.—The invention relates to an anti-vibration suspension device of the kind in which the supported member is connected to the supporting member by a flexible or resilient member comprising woven or braided material such as wire gauze. According to the invention, the flexible or resilient member comprises woven or braided material, such as wire gauze, having cuts or lines of holes, either straight or curved,



transverse to the dimension between the supporting and the supported members. The flexible or resilient member may be in the form of a ring or annulus with the cuts or lines of holes transverse to its radii, or may be of cylindrical or truncated cone form connected at one part to the supporting member and at another part to the supported member. 1 is an annulus of wire gauze mounted in an outer metal ring 2 and an inner metal ring 3. The gauze has cuts 4 which are transverse to the radii of the annulus, and which are staggered in relation to each other, and, in the example, are of such length that no complete strand of the gauze connects the outer and inner rings 2 and 3. (*Sealed.*)

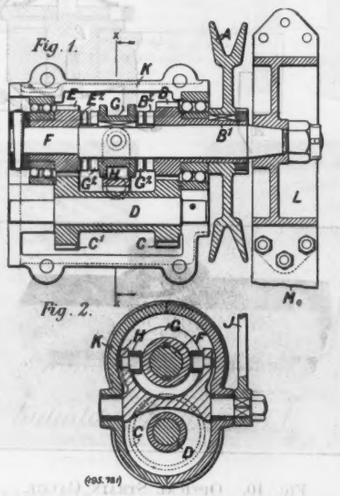
GAS ENGINES, PRODUCERS, HOLDERS, &c.

195,737. A. A. M. Durrant, Dulwich, London, and The London General Omnibus Company, Limited, Westminster. Internal-Combustion Engines. (4 *Figs.*) January 4, 1922.—The invention is for apparatus for regulating the combustible mixture in internal-combustion engines. The type of apparatus to which the invention relates is that wherein a conduit for the supply of an anti-detonating agent to the engine cylinder is controlled by a valve which is operated by a movable member, such as a piston, the movement of which is controlled by the suction action produced by the partial vacuum in the main fuel and air passage of the engine. According to the invention, apparatus for regulating the combustible mixture in internal-combustion engines is characterised by the fact that a spring acts on the movable member in such a manner as to tend to open the valve against the action of the suction effect which controls the movement of the movable member. 10 is the engine induction pipe, 11 the main throttle and 12 the carburettor. Clamped between flanges 13, 14 is a lug 15, which projects from a valve



casing 17 having bosses 18, 19, which are bored to form a through-way 20. The boss 18 is coupled to a supply of the anti-detonating agent, and the boss 19 is coupled to a conduit 21 leading to the air intake of the carburettor 12. The casing 17 is closed at its top by a cap 22, below which is situated a valve 23 that controls the passage 20. The valve 23 is of conical formation. The passage 20, where it passes the valve 23, is increased in width (at 26, Fig. 3), and is provided with ribs 27, which also form seatings for the valve. When the valve is down upon its seatings the passage 20 is closed. The valve 23 is secured upon a stem 28 secured at its lower end to a flexible diaphragm 30. The outer edges of the diaphragm 30 are secured by a clamping ring 32, and below the clamping ring there is screwed into the casing 17 a cap 33 with a detachable plug 34. The plug 34 is recessed to house a spring 36 which tends to open the valve 23. The diaphragm 30 divides the casing 17 into two separate chambers 38, 39. The chamber 38 has a vent to provide communication with the outside and the chamber 39 is in communication with the interior of the engine induction pipe 10 on the cylinder side of the throttle 11. For this purpose the passage 40 is provided, and in this way communication is established between the interior of the induction pipe 10 and the chamber 39, the smallness of the bore operating to damp the fluctuations in pressure and secure regularity in the movements of the diaphragm due to such fluctuations in pressure. In operation, it will be appreciated that when the engine compression is high, there will not be a very considerable vacuum established in the engine induction pipe; consequently the difference in pressures in the two chambers 38 and 39 will be such that the spring 36 will be able to open the valve 23. When, however, the compression in the cylinder falls, the vacuum in the induction pipe will become greater, and this will operate to maintain the valve 23 closed despite the pressure of the spring 36. The spring 36 may be made adjustable to vary the amount of vacuum required to close the valve. (*Sealed.*)

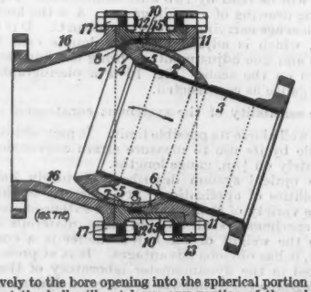
195,781. A. D. Mackenzie, Mayfair, London. Cooling Fans. (2 *Figs.*) January 12, 1922.—The invention relates to the cooling fans for motor car engines. In accordance with the invention, the hub of the fan is fitted with a variable speed gear, the variation in speed of which is controlled from an attachment to the steering column. The gearing shown provides a neutral or stationary position for the fan impeller, a speed of the runner equal to that of the belt pulley, and a second speed of about 28 per cent. greater. A is the fan belt pulley which is mounted on and keyed to an extension B1 of the boss of a pinion B, which is free to revolve on the fan shaft F. The pinion B meshes with a pinion C which is free to revolve on a stationary countershaft D. Integral with the pinion C is a pinion C1, which meshes with a pinion E, which is free to revolve on the shaft A. The pinions B and E are formed with dog clutch teeth B2, E2, while an intermediate clutch element G, so mounted on the shaft F that it is constrained to revolve with the shaft F but is free to slide longi-



tudinally thereon, has corresponding dog clutch teeth G2 cut in both its end faces. To the fork H, which engages with the clutch element G, is secured a lever J worked from the driver's seat. The whole gearing is enclosed in a casing K. One end of the main shaft F projects through the casing, and carries the fan runner or centre piece L to which are fitted the fan blades, one of which is shown partly broken away at M. The drawing shows the clutch element G disengaged from both pinions B and E. In this position the fan runner is stationary although the belt pulley A may be revolving. When the lever J is moved to cause the clutch element G to engage the pinion B, the main shaft F and the fan are revolved at pulley speed. When the lever J is shifted to bring the clutch element G into engagement with the pinion E, a different speed of rotation is given to the shaft F and to the fan, according to the ratio of the gears, as the transmission is now from the pinion B to the pinions C, C1, and so through the pinion E and clutch element G to the main shaft F. (*Sealed.*)

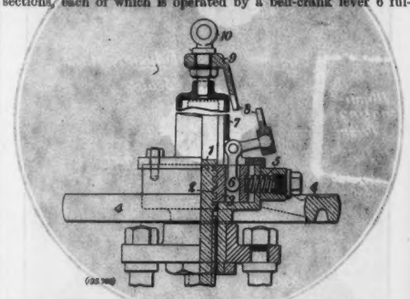
HYDRAULIC MACHINERY.

195,772. W. H. Dorman and Co., Limited, Stafford, and O. H. G. Steed, Stafford. Pipe Joints. (2 *Figs.*) January 10, 1922.—The invention comprises a pipe joint of the kind having a ball at one end of one pipe of the joint fitting in a spherical socket at the adjacent end of the other pipe of the joint, and wherein the bore of the ball is conical at its outer end, characterised by the larger end of the conical bore in the ball being of such a



size relatively to the bore opening into the spherical portion of the socket, that the ball will not leave any portion of the spherical bearing surface of the ball socket exposed to the contents of the pipe when the joint is bent to its angle of limit. The ball 2 of the joint is screwed on the end of a pipe section 3, the bore in the ball 2 is made conical at 4, and parallel for its remaining portion. This parallel portion of the bore is screwed at the end 5 to fit on the end of the pipe 3, while at the other end it is bored to form a plain bearing on the pipe 3, the intermediate portion of the ball being hollow. The conical portion 4 terminates at the periphery of the ball, and is of such a size that relatively to the spherical bearing surface 7 in the ball socket 10, it does not leave any portion of the spherical surface 7 exposed to the contents of the pipe when the joint is bent to its angle of limit as shown. It will thus be seen that the material passing through the pipe will have an abrading action only on the inner conical portion 4. The packing 8 is of the U-shaped type held between the two portions 7 and 9 of the spherical surface formed respectively on the socket and gland portions 10 and 11 of the pipe joint, the portions 10 and 11 being adapted to hold the ball 2 between them. The open end of the U-shaped packing 8 is arranged towards the gland, and is provided with a wedge-shaped ring 12 extending partially within the open end of the ring 8, and has a plain back portion 15 bearing against the inner end of the gland 11. The gland 11 is bolted on the socket portion 10 in the usual manner by bolts 13, and adjustment between its inner end and the back of the wedge ring 12 may be effected by interposing rings of thin material. The other pipe of the joint is connected by means of a flanged member 16 and bolts 17 to the pipe socket 10, and the pipe 3 is connected to the system of piping by a flange. (*Sealed.*)

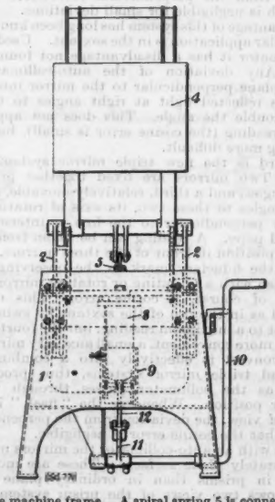
195,702. James Howden and Co., Limited, Glasgow, and C. W. Hume, Glasgow. Sluice or Gate Valves. (2 *Figs.*) December 9, 1921.—The invention relates to sluice or gate valves of the type in which the closure of the valve element is effected by a spring acting automatically on the withdrawal of a detaining device controlled from a remote position, the detaining device being of the type comprising spring-pressed nut sections engageable with, and disengageable from, a threaded portion of the valve spindle. The valve shown includes a spindle 1 provided with a sunk thread at 2 engaged by a divided nut 3 mounted on the hand-wheel 4, which serves for normal operation of the valve, the divided nut being normally held in engagement with the spindle by means of springs 5. The divided nut comprises three sections, each of which is operated by a bell-crank lever 6 ful-



crummed on a cap 7 which houses the upper end of the spindle 1. One end of each bell-crank lever 6 engages a socket in a corresponding nut section 3 and the other end of each bell-crank lever 6 which is in connection with one arm 8 of a spider structure 9 terminating beyond the upper end of the spindle and fitted with an eyebolt 10 to which is secured the end of the emergency operating cord or the like (not shown). In operation, the valve is moved into open position in opposition to the main spring (not shown) by means of the hand wheel 4. When the valve is to be closed, in case of emergency, the operating cord is pulled, whereby the spider frame 9 is moved axially so as to rock the bell-crank levers 6 and cause the nut sections 3 to be moved radially, or substantially radially, out of engagement with the spindle 1 where the valve is permitted to close under the action of the main spring. (*Accepted April* 18, 1923.)

MINING, METALLURGY AND METAL WORKING.

195,771. P. Pritchard, Moseley, Birmingham. Foundry Moulding Machines. (4 *Figs.*) January 10, 1922.—The invention comprises certain improvements in hand ramming foundry moulding machines. According to the improvements, the foundry moulding machine comprises a frame 1 to which a tamping plate 4 is pivoted, a support for receiving the pattern plate and moulding box lifting mechanism carried by the frame. The tamping plate 4 is pivoted to an adjustable bracket 2, which is



fixed to the machine frame. A spiral spring 5 is connected at one end to rear lugs on the tamping plate, and at the other end to an adjustable bolt or member to adjust thereby the force of the spring on the tamping plate. The mould-lifting mechanism comprises a cylindrical or tubular member 8, which can slide in a tubular bearing 9 carried by the frame, and is operated by means of a lever 10, an arm 11 of which is connected by a link 12 to the cylindrical or tubular member 8. (*Sealed.*)